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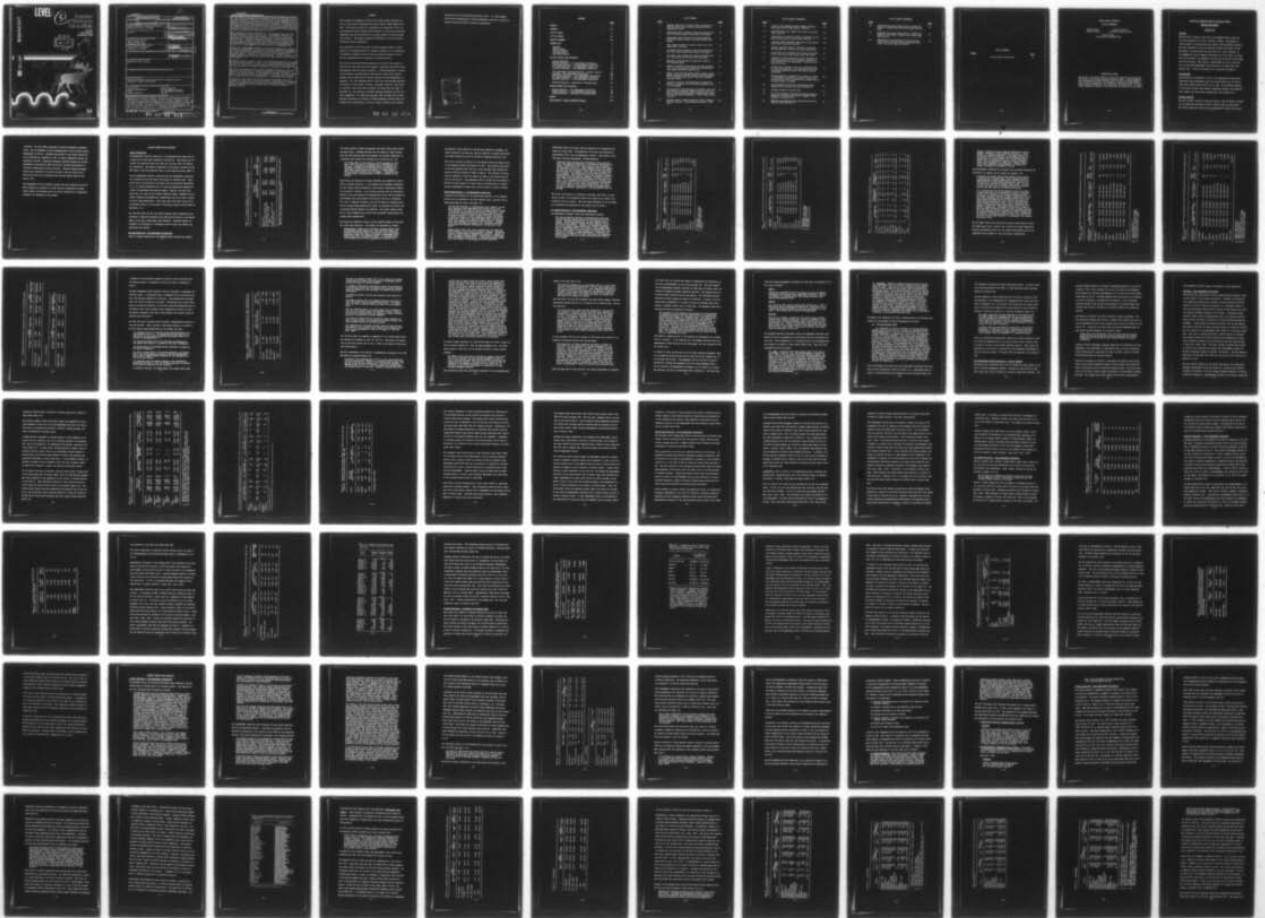
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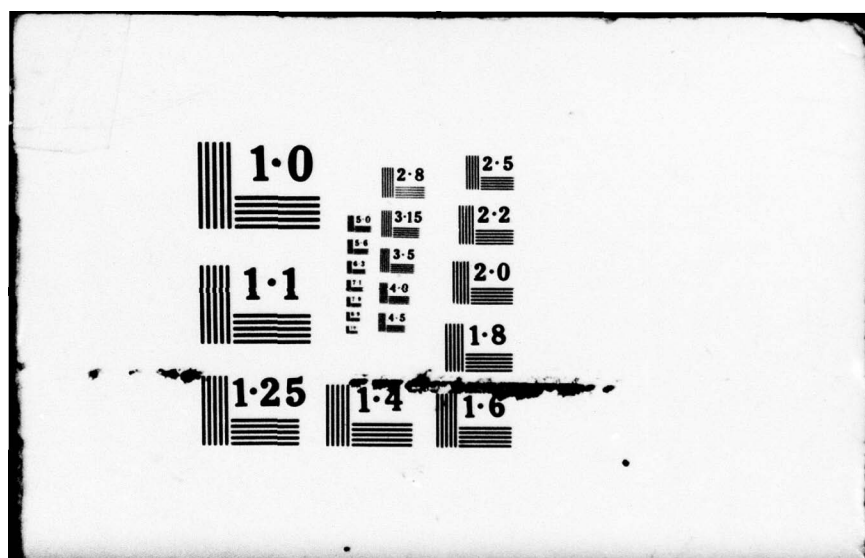
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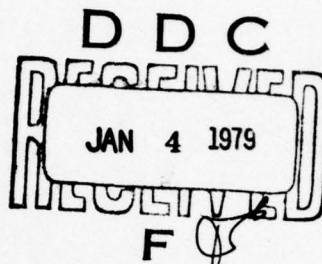


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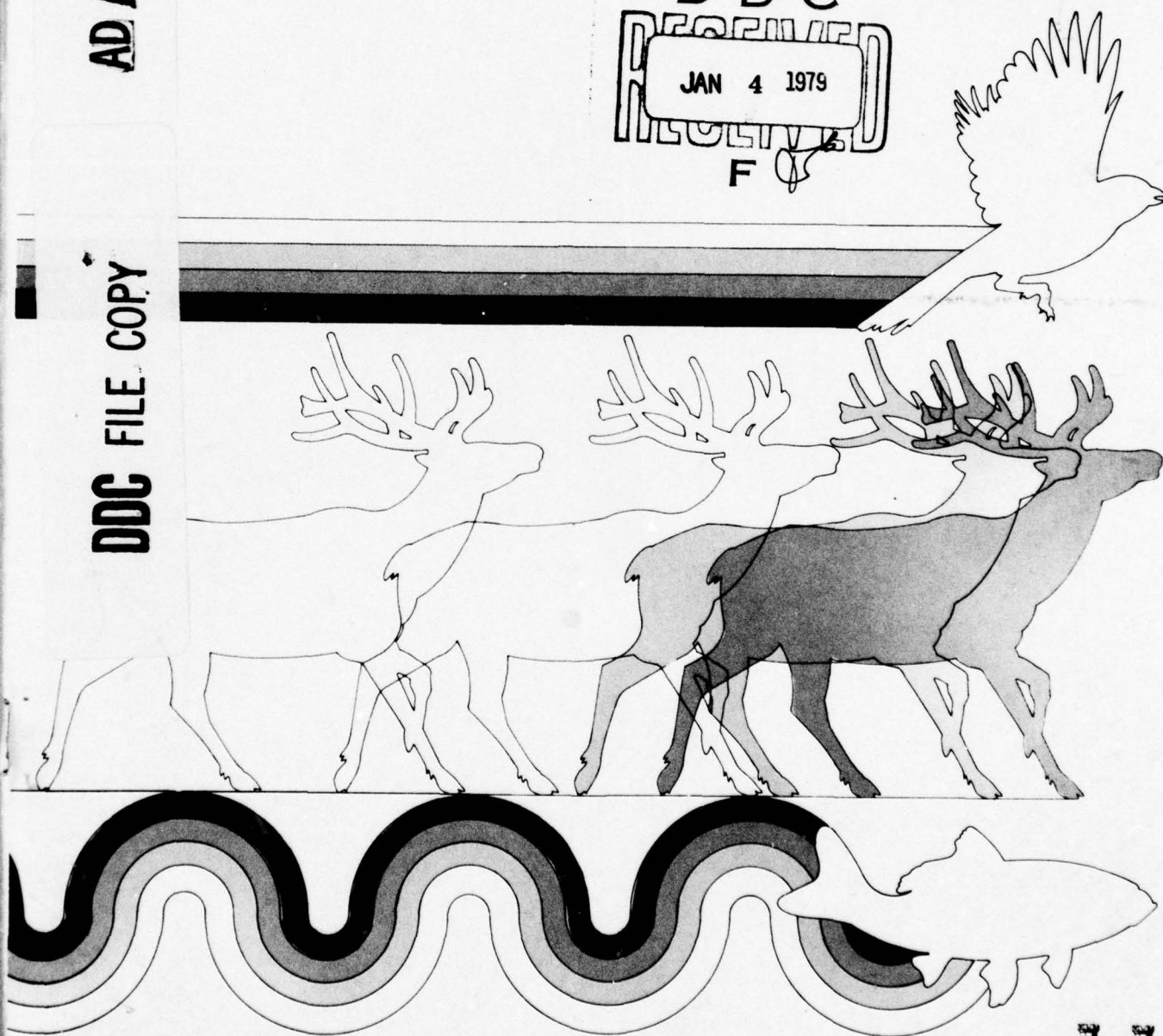
Evaluation of Planning for Fish & Wildlife

**Carlyle
Lake Project
November 1978**



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<table border="0"> <tr> <td>Fish resources</td> <td>Wildlife resources</td> </tr> <tr> <td>Planning recommendations</td> <td>Pre-impoundment predictions</td> </tr> <tr> <td>Carlyle</td> <td>Post-impoundment occurrences</td> </tr> <tr> <td>Planning evaluation</td> <td>Illinois</td> </tr> </table>			Fish resources	Wildlife resources	Planning recommendations	Pre-impoundment predictions	Carlyle	Post-impoundment occurrences	Planning evaluation	Illinois
Fish resources	Wildlife resources									
Planning recommendations	Pre-impoundment predictions									
Carlyle	Post-impoundment occurrences									
Planning evaluation	Illinois									
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Carlyle Lake, which covers 10,522 ha (26,000 ac) at normal pool is the largest impoundment in the State of Illinois. Construction was initiated by the St. Louis District of the Corps of Engineers (CE) in 1964 and completed in 1967. The FWS report was prepared in 1954, appended to the CE survey report, and submitted to Congress in 1957. The project was authorized by the Flood Control Act of 1958, and therefore fell under the full purview of the 1958 Amendments to the Fish and Wildlife Coordination Act. — (Continued next page) —										

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CONT. The FWS provided 12 fish and wildlife-related planning recommendations, several of which constituted affirmations of proposed CE design and operational plans for the project and several others which were important, through pro forma articles generally contained in every FWS report of that time-period. With the important exception of the recommended timber clearing, later amended at the request of the conservation agencies to allow standing timber to remain in the upper section of the summer pool, all but one of the six site specific recommendations were implemented by the construction agency. The FWS's recommendation to acquire additional land for wildlife was not implemented by the CE.

The CE acquired in fee only those lands up to the programmed five-year flood frequency elevation of 137.2 m (450 ft) msl. Sub-impoundment dikes were constructed by the State with a crown elevation of 137.2 m msl, to convert the upper section of the project-acquired acreage into a "green-tree" waterfowl management area. Flood-water storage has exceeded 137.2 m msl during 7 years of the 11 years of record. In 1973 and 1974, flood water was retained in the sub-impoundments for extended periods which resulted in killing approximately 80 percent of the mast-producing trees located in the sub-impoundment area.

Although the sub-impoundment complex has not operated successfully as a green-tree facility, waterfowl use of the project area has increased from approximately one million duck-days/year (pre-project) to just under seven million duck-days/year (post-project). Goose use of the project area also increased from a negligible amount to just over one million goose-days. Harvest of waterfowl has averaged approximately 7,550 birds annually (200 geese; remainder ducks) during recent years.

The apparent losses in squirrel, rabbit, quail and opossum populations far exceeded the pre-project estimates. Contrary to the predicted basinwide adverse impact on deer, it is clear that the project impacts on deer resources were localized and directly related to the amount of deer habitat flooded by the permanent pool.

The Carlyle Lake fishery is vastly superior to predicted conditions. The introduction of non-native species, though not considered in the pre-construction period, has contributed greatly to this valuable recreational enterprise. Angling effort on the lake and tailrace is approximately 5.3 times the level predicted, and the recreational harvest is approximately 6.6 times higher than predicted.

The Kaskaskia River channel below the dam suffered serious bank erosion and lounging as a direct result of project operation as compounded by the miscalculation of the non-damaging channel capacity by the construction agency. Releases have been moderated by the CE in recent years to curtail the streambank degradation problem.

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PREFACE

This document was prepared by staff of the Sport Fishing Institute for the U.S. Army Corps of Engineers (CE) under contract number DACW73-74-C-0040. The contract requires the compilation and comparison of pre- and post-construction data treating fish, wildlife, or both fish and wildlife (depending upon data availability) for twenty separate CE water development projects. This report presents the findings for one of the twenty individual project evaluations.

Upon completion of the full series of twenty separate studies, a final report will be prepared which will contain an analysis of the validity of the predictive procedures used in fish and wildlife planning, and will contain recommendations for improving the planning process.

This study of fish and wildlife planning at the Carlyle Lake project in Illinois was aided greatly by the cooperative assistance provided by many knowledgeable state and federal personnel. Illinois Department of Conservation personnel including Messrs. William Boyd, Arnold Fritz, Merrell Collins, Floyd Kringer and Tom Johnson supplied the post-impoundment information. Mr. John Powpowski and Mr. Bruce Kline with the Fish and Wildlife Service in Rock Island, Illinois, and Messrs. Owen Dutt, Dick Cameron, Jay Gore, Jerry Vaill and Al LeGrand, and others with the Corps of Engineers, St. Louis District, provided necessary documents and many valuable suggestions. Mr. Maury Spletstaszer, FWS (retired) and Dr. Edwin Herricks, University of Illinois at Urbana-Champaign, offered helpful information and recollections, as did Dr. Wendell Larrimore and Dr. Frank

Bellrose with the Illinois Natural History Survey. Dr. Keith Harmon, North Central Representative, Wildlife Management Institute, visited the project area and critically reviewed the manuscript.

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CONTENTS

	<u>PAGE</u>
PREFACE	1
CONTENTS	iii
LIST OF TABLES	iv
LIST OF FIGURES	vii
PROJECT PERSONNEL	viii
INTRODUCTION	1
Location	1
Authorization	1
Physical Features	1
Area Description	3
Descriptive Reports	3
WILDLIFE RESULTS AND DISCUSSION	5
General Discussion	5
Big Game Resources -- Pre-impoundment Predictions	5
Upland Game Resources -- Pre-impoundment Predictions	8
Fur Animal Resources -- Pre-impoundment Predictions	9
Waterfowl Resources -- Pre-impoundment Predictions	16
Post-impoundment Wildlife Resources -- General Comments	27
Big Game -- Post-impoundment Occurrences	29
Upland Game Resources -- Post-impoundment Occurrences	38
Fur Animal Resources -- Post-impoundment Occurrences	41
Waterfowl Resources -- Post-impoundment Occurrences	43
Wildlife Resources -- Evaluation of Planning Input	50
FISHERY RESULTS AND DISCUSSION	61
Fishery Resources -- Pre-impoundment Predictions	61
Fishery Resources -- Post-impoundment Occurrences	70
Fishery Resources -- Evaluation of Planning Input	86
SUMMARY	94
BIBLIOGRAPHY OF SOURCE REFERENCE MATERIAL	100

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	Physical dimensions of Carlyle Lake as presented in 1954 FWS report and as actually constructed by CE (completed in 1967)	6
2	Upland game values assigned by Fish and Wildlife Service for Carlyle project area without the project	10
3	Upland game values projected by Fish and Wildlife Service for Carlyle project area after project completion	11
4	Cover types and areas at Carlyle project site, Kaskaskia River, Illinois	12
5	Fur animal values assigned by Fish and Wildlife Service for Carlyle project area without the project	14
6	Fur animal values projected by Fish and Wildlife Service for Carlyle project area with the project	15
7	Waterfowl visitation data as predicted by FWS for 1954 planning report	18
8	Summary of wildlife values before and after construction of Carlyle project as related in 1954 FWS planning report (unpolluted figures only)	20
9	Number of deer hunting permits issued, number of deer bagged, and hunter success (number of deer killed/permit) from Carlyle Lake project lands and contiguous counties, 1960-77	31
10	Location, by county, and disposition of property acquired in conjunction with the Carlyle Reservoir project development	33
11	Relationship of hunting pressure and habitat loss with deer harvest from project lands in Clinton, Bond, and Fayette Counties (data reflects average annual values for each time period specified). Carlyle Lake project, 1960-1977	34
12	Reservoir Basin clearing regimes in Clinton, Fayette, and Bond Counties. Carlyle Reservoir project, 1964-1965	35

LIST OF TABLES (CONTINUED)

<u>Table</u>		<u>Page</u>
13	Summary of IDC Pheasant Release Program at Hazlet State Park, Carlyle Lake project, 1969-1977	42
14	Waterfowl hunter use, harvest and success at Carlyle Lake, 1972-1977	46
15	Distribution of waterfowl hunters and harvest at each major hunting area at Carlyle Lake, 1972-1973	48
16	Available aerial waterfowl count data for the Carlyle Lake project area from 1975-1978	49
17	Expanded estimated number of duck-days, goose-days and coot-days for 1975-1978 at Carlyle Lake project	51
18	Harvest per unit of habitat data utilized by the FWS in the 1954 Carlyle Lake Project Basin Data Report	52
19	Comparison of FWS "without-the-project estimates" of wildlife harvest and "with-the-project predictions" with observed 1977 post-impoundment occurrences estimated by the IDC	55
20	Average annual waterfowl counts for Mississippi Flyway (includes Illinois); data tabulated for pre-Carlyle period (1960-1966) and for post-Carlyle period (1967-1978)	57
21	Breeding population estimates for 10 species of ducks (in thousands); evaluated for period of record preceding construction of Carlyle and for period following construction of Carlyle	58
22	Pre-impoundment fishery data from Kaskaskia River within the 105.3 km (62.2 mi) Carlyle Lake site	65
23	Stocking records for Carlyle Lake	73
24	List of fish species collected from Carlyle Lake and tailwaters (from Fish and Wildlife Management Plan, Appendix D to Master Plan)	76
25	Expanded creel statistics for Carlyle Lake and tailwater for 1966-1969 and 1971	78

LIST OF TABLES (CONTINUED)

<u>Table</u>		<u>Page</u>
26	Estimated total sport fishery catch in number and weight for Carlyle Lake from 1966 through 1969 and 1971	81
27	Estimated total sport fishery catch in number and weight for the Carlyle tailwater from 1966 through 1969 and 1971	83
28	Comparison of angling-effort and harvest predictions (1954), and actual effort and harvest data (1977) for Carlyle Lake and tailrace	93

Figure

Map of Carlyle Lake project

2

SPORT FISHING INSTITUTE

PROJECT PERSONNEL

Robert Martin
(Project Leader)

Norville Prosser
(Assistant Project Leader)

Richard Stroud
(Contractor's Representative)

CONSULTANT'S REVIEW

Professional terrestrial wildlife consultative services were provided by the staff of the Wildlife Management Institute (WMI). Project personnel were accompanied by a WMI staff specialist during field reconnaissance and on on-site discussions. The terrestrial wildlife portion of the prepared evaluative manuscript was reviewed and evaluated by WMI. All pertinent suggestions offered by the consultant are reflected in this report.

INDIVIDUAL RESERVOIR PROJECT EVALUATION REPORTS

CARLYLE LAKE PROJECT

INTRODUCTION

Location

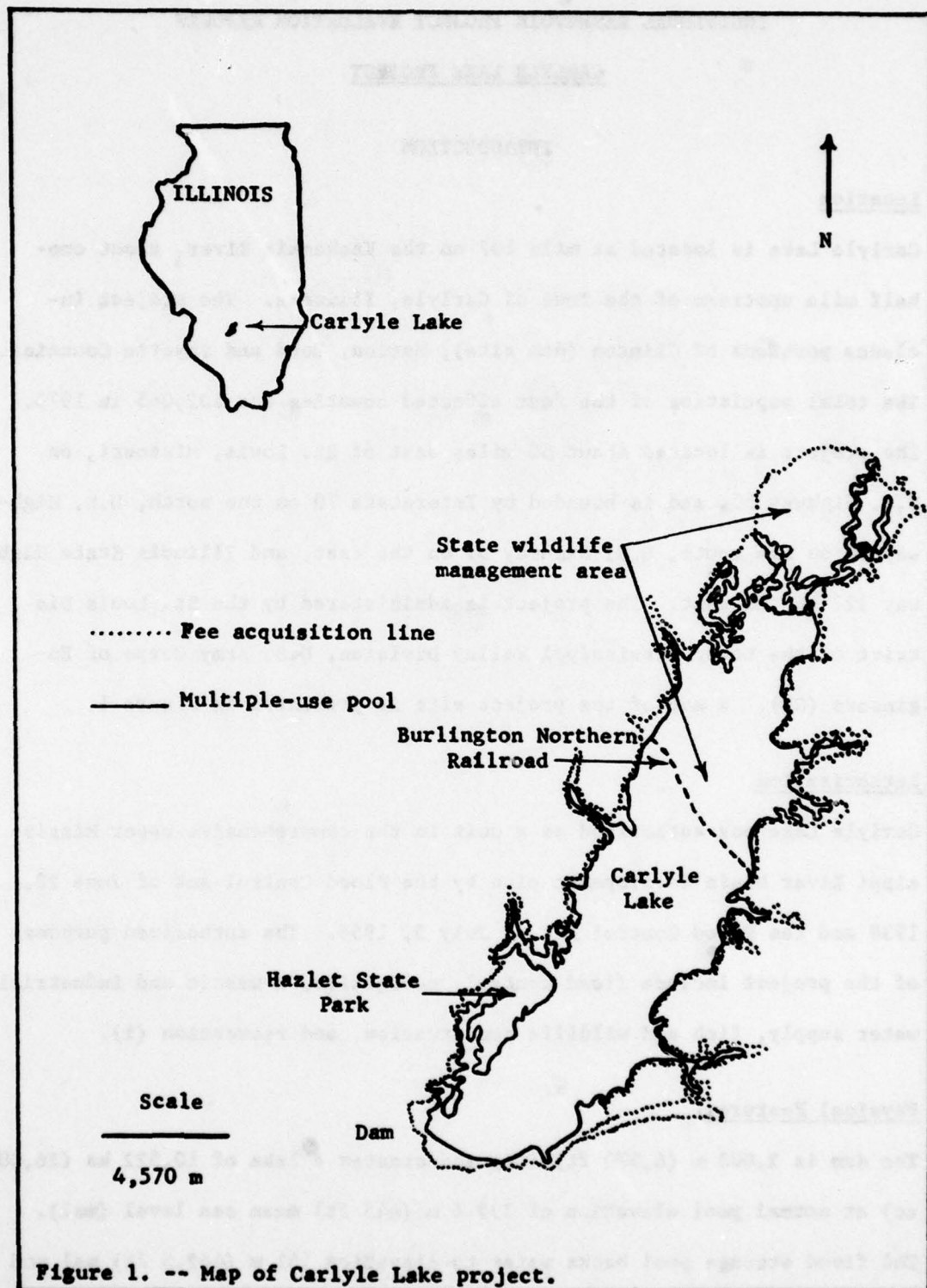
Carlyle Lake is located at mile 107 on the Kaskaskia River, about one-half mile upstream of the Town of Carlyle, Illinois. The project includes portions of Clinton (dam site), Marion, Bond and Fayette Counties. The total population of the four affected counties was 102,065 in 1970. The project is located about 50 miles east of St. Louis, Missouri, on U.S. Highway 50, and is bounded by Interstate 70 on the north, U.S. Highway 50 on the south, U.S. Highway 51 on the east, and Illinois State Highway 127 on the west. The project is administered by the St. Louis District of the Lower Mississippi Valley Division, U.S. Army Corps of Engineers (CE). A map of the project site is presented in Figure 1.

Authorization

Carlyle Lake was authorized as a unit in the comprehensive upper Mississippi River basin development plan by the Flood Control Act of June 28, 1938 and the Flood Control Act of July 3, 1958. The authorized purposes of the project include flood control, navigation, domestic and industrial water supply, fish and wildlife conservation, and recreation (1).

Physical Features

The dam is 2,003 m (6,570 ft) long and creates a lake of 10,522 ha (26,000 ac) at normal pool elevation of 135.6 m (445 ft) mean sea level (msl). The flood storage pool backs water to elevation 141 m (462.5 ft) msl and



covers 23,270 ha (57,500 ac). The normal pool stores $2.9 \times 10^8 \text{ m}^3$ (233,000 ac ft) and $8.6 \times 10^8 \text{ m}^3$ (700,000 ac ft) are stored at full flood storage. At normal pool, the lake has a shoreline of 88.5 km (55 mi) and a maximum depth of 12.2 m (40 ft). The fee line contour (programmed five-year flood elevation) is at 137 m (450 ft) msl and the easement line contour is at 142 m (465.5 ft) msl. At the fee contour, the project embraces 15,038 ha (37,159 ac) including 4,516 ha (11,159 ac) of land. The project provides a minimum release of 50 cfs and a maximum release of 10,000 cfs to the Kaskaskia River below the dam.

Area Description

The topography of the project area is gently rolling with alluvial valleys and terraces along the Kaskaskia River. The surrounding land is relatively flat farm land. The soils are generally glacial tills with moderate internal drainage (2). The climate is moderate, having an average annual temperature of approximately 13°C (55°F). The prevailing winds are from the south, southwest. Average annual precipitation is approximately 1.0 m (38.6 in) (3).

Descriptive Reports

Only one report was prepared which contained specific estimates of pre-project and probable post-project fish and wildlife resources. This report, which was prepared by the Fish and Wildlife Service (FWS), was released February 23, 1954 (4). The FWS's impact assessments, all in monetary terms, were utilized by the CE in preparation of their Survey Report of the Kaskaskia River (5) upon which the Congress authorized project con-

struction. The 1954 report contained 12 specific management recommendations. The CE responded to these recommendations in their General Design Memorandum of 1958 (6). Although construction of the Carlyle project began in 1958 and was completed in 1967, no formal supplemental report was prepared by the FWS. Cooperative planning continued between the Illinois Department of Conservation (IDC) and the CE, with FWS participation restricted to monitoring of these activities. Detailed planning recommendations were submitted to the CE by the IDC in 1961 and 1962 (7,8,9). These state plans were incorporated into the CE's Master Plan for the project (10).

Post-impoundment fish and wildlife studies have been conducted by the IDC. These findings are contained in a wide variety of published and unpublished reports and documents which are quoted individually as appropriate throughout the remainder of this report.

WILDLIFE RESULTS AND DISCUSSION

General Discussion

Pre-impoundment wildlife conditions in the Kaskaskia River Basin were described in the 1954 report prepared by the FWS (4). This report also described the conditions which were expected to prevail after the project was constructed. The physical dimensions of the project evaluated by the FWS staff in 1954 were basically those of the completed project (Table 1).

The pre-impoundment wildlife conditions and post-impoundment predictions were discussed in the 1954 report exclusively in monetary terms. These values were not associated in the report with any particular methodology (i.e., no wildlife population data nor user-day information) employed as a basis for generating the monetary figures. However, the basic data, which were not a part of the formally submitted report, contained the conceptual framework and mathematical computations used by the FWS to obtain the final impact predictions. These basic data files were located after considerable effort in the Division of Ecological Service offices (FWS) in Washington, D.C.

The 1954 FWS report was the only formal planning report submitted by the responsible conservation agencies that addressed the project's anticipated impact on big game, upland game, and furbearers. Waterfowl habitat development was discussed in a succeeding series of state and federal communications and reports.

Big Game Resources -- Pre-impoundment Predictions

Prior to project construction, the Kaskaskia River bottoms were covered

Table 1. -- Physical dimensions of Carlyle Lake as presented in 1954 FWS report and as actually constructed by CE (completed in 1967)

Item	Elevation (ft msl)		Area (ac)	
	Anticipated	Actual	Anticipated	Actual
Top of dam	474.0	472.5	--	--
Maximum flood control pool	462.5	462.5	57,500	58,447
Average annual maximum pool	447.1	450.7*	29,000	34,193*
Navigation pool (normal pool)	445.0	445.0	26,000	26,000
Average annual minimum pool	440.3	436.6*	19,500	14,474*
Conservation pool	430.0	429.5	6,500	7,100

* Average annual maximum and minimum levels recorded for eleven-year period 1967-1977 (data supplied by St. Louis District)

with dense stands of timber interspersed with small agricultural fields and small lakes. Although big game were not subject to legal hunting when the 1954 planning report was prepared, the economic importance of a potential deer harvest was considered in the write-up (4), viz:

The bottom lands in the vicinity of Carlyle sustain 15 to 25 deer. Food and cover are available for a substantially larger herd. Assuming the decimating factors of poaching and harassment by dogs will be curtailed as the possibility of a legal deer season becomes more certain, it seems probable that the Carlyle deer herd would increase. A potential without-the-project big game harvest of \$800 is assigned Carlyle Project.

Construction and operation of Carlyle Reservoir was expected to cause a loss to wildlife resources. It was expected that permanent flooding below the average annual minimum pool would destroy irreplaceable habitat for terrestrial wildlife. It was further believed that the terrestrial habitat in the zone between the navigation-pool level and the average annual minimum level would suffer an 80 percent loss due to inundation. Also, due to temporary flooding in the area between the navigation pool and the average annual maximum pool levels, an estimated 10 percent loss of existing wildlife habitat was predicted. The report further stated that no loss of habitat would result from infrequent flooding above the average annual maximum pool.

The project was expected to have a serious negative impact on the potential local deer population. This impact was described as follows:

Approximately 17,000 acres of potential big-game habitat would be destroyed through inundation. This loss would reduce the potential annual deer value of the Carlyle area by 60 percent, and greatly reduce the chance of success in developing a permanent deer herd in the Kaskaskia Basin. An estimated potential big-game value of \$270 is assigned the affected area.

The monetary values supplied by the FWS were computed by assuming a potential harvest of one deer per 2,025 ha (5,000 ac) of upland and bottom-land timber within the 23,270 ha (57,500 ac) maximum flood pool (11).

There were 11,130 ha (27,500 ac) of such habitat within the project area, so the potential harvest was placed at 6 deer. This resource was valued at \$136 per harvested deer (12) for a total big game value without-the-project of \$816.00 (rounded to \$800 in report). The creation of Carlyle Lake was expected to reduce the amount of timber in the project area by 6,743 ha (16,662 ac). The remaining 4,386 ha (10,838 ac) was expected to provide an annual harvest of 2 deer valued at \$136.00 each or a remaining post-impoundment big game value of \$272 (rounded to \$270 in report).

Upland Game Resources -- Pre-impoundment Predictions

A qualitative description of the upland game resources of the proposed project area was provided in the 1954 planning report, together with an upland game monetary value of \$22,600, viz:

Fox and gray squirrels, in approximately equal numbers, are the most important upland game species within the project area. Their population is relatively stable, although a shift to higher elevations is noticeable during period of inundation. Neither the wet timbered bottoms nor the intensively cultivated peripheral uplands are suitable habitat for quail and rabbits. A substantial number of these upland-game species utilize the field cover, hedge areas, pastured timber lands, and roadside ditch cover between the bottoms and midland plains. Mourning doves nest throughout the project area. Raccoons, red foxes, and opossums are steadily increasing in all portions of the basin.

Hunters from as far as St. Louis, Missouri hunt the Kaskaskia River bottoms in the vicinity of Carlyle, Illinois. The annual harvest of upland game is predominantly squirrels. Rabbits and quail are taken in lesser numbers. Other forms of upland game have a negligible sporting value. A without-the-project upland game value amounts to \$22,600 for the Carlyle Reservoir.

Upland game within the project area was expected to be dramatically affected by Carlyle Lake. The magnitude of the losses was projected at approximately 50% of the pre-impoundment resource. With respect to upland game, following impoundment, the FWS predicted:

Inundation below average annual minimum pool level would destroy approximately 19,000 acres of diversified upland game habitat. An additional 4,000 acres would be lost by frequent flooding above this level. These combined losses would reduce the available fox and gray-squirrel habitat within the Carlyle Reservoir pool by 50 percent. Since this type of timber habitat is limited, the ramifications of this loss should not be underestimated. Other forms of upland game normally occupying woody areas would be adversely affected. Population and harvest values would decrease proportionately to this loss of habitat. It is estimated that 25 percent of the cottontail and quail values would be lost because of inundation and detrimental effects caused by water level manipulations. The total loss to all species of upland game within the maximum pool is estimated at \$10,900, resulting in a with-the-project value of \$11,700.

The actual calculations, as contained in the basic data files, are presented in Table 2 for conditions without the project and in Table 3 for conditions with the project. The cover types displayed on the two tables are identified and quantified for the project area in Table 4.

Fur Animal Resources -- Pre-impoundment Predictions

Pre-impoundment furbearer values were described as follows:

The land-use pattern includes an interspersed of semi-wild land and provides superior habitat for the protection of fur animals. Raccoon and opossum are the most abundant species present. Forest-bordered streams and small lakes are utilized by mink and muskrats. However, the intermittent character of the streams, general deficiency in aquatic vegetation, and oil contamination have had an effect on the muskrat population. Mink, which are less affected by polluted water, have been able to sustain a constant population. Terrestrial fur animals such as weasels, red foxes, gray foxes, and skunks occupy the fringe areas and the open cultivated plots adjacent to the timber.

Table 2. --- Upland game values assigned by Fish and Wildlife Service for Carlyle project area without the project

Wildlife group and species	Type and area used		Approx. harvest per unit of habitat	Approx. total harvest	Unit value	Total value
	Cover type	Ha (Ac)				
Upland game						
Fox & gray squirrel	TB and TU	11,129 (27,500)	1 per 4 acres	6,875	\$2.04	\$14,025.00
Cottontail rabbit	A-1-2-3-4-6	11,484 (28,376)	1 per 20 acres	1,419	1.36	1,929.84
Quail	A-1-2-3-4-6	11,484 (28,376)	1 per 32 acres	887	6.80	6,031.60
Raccoon	All types	23,270 (57,500)	1 per 500 acres	78	4.08	318.24 ^a
Red fox	All types	23,270 (57,500)	1 per 3,000 acres	6	6.80	40.80 ^b
Gray fox	All types	23,270 (57,500)	1 per 4,000 acres	1	6.80	6.80 ^c
Opossum	All types	23,270 (57,500)	1 per 842 acres	49	1.36	66.64 ^d
Mourning dove	All types	23,270 (57,500)	3 adults per section	121,000 ^e	.0019	229.78
Total value						\$22,648.70

- a. 67.6% by hunter
b. 30.0% by hunter & 70% by trapper
c. 9.5% by hunter & 90.5% by trapper
d. 72% by hunter & 28% by trapper
e. Use days

Table 3 . -- Upland game values projected by Fish and Wildlife Service for Carlyle project area after project completion

Wildlife group and species	Type and area used		Approx. harvest per unit of habitat	Approx. total harvest	Unit value	Total value
	Cover type	Ha (Ac)				
Upland game						
Fox & gray squirrel	TB and TU	4,386 (10,838)	1 per 4 acres	2,710	\$2.04	\$ 5,528.40
Cottontail rabbit	A-1-2-3-4-6	8,572 (21,182)	1 per 20 acres	1,059	1.36	1,440.24
Quail	A-1-2-3-4-6	8,572 (21,182)	1 per 32 acres	662	6.80	4,501.60
Raccoon	All types	13,149 (32,490)	1 per 500 acres	4	4.08	187.68 ^a
Red fox	All types	13,149 (32,490)	1 per 3,000 acres	3	6.80	20.40 ^b
Gray fox	All types	13,149 (32,490)	1 per 4,000 acres	1	6.80	6.80 ^c
Opossum	All types	13,149 (32,490)	1 per 842 acres	28	1.36	38.08 ^d
Mourning dove	All types	13,149 (32,490)	3 adults per section	68,421 ^e	.0019	12.97 ^f
Total value						\$11,736.17

- a. 67.5% hunter
b. 30.0% by hunter & 70% by trapper
c. 9.5% by hunter & 90.5% by trapper
d. 72% by hunter & 28% by trapper
e. Dove use-days
f. Error, should have been \$130.00

Table 4. -- Cover types and areas at Carlyle project site, Kaskaskia River, Illinois

Cover type	Sym.	Conservation pool		Conservation pool to navigation pool		Navigation pool to maximum pool		Total	
		Ha	(Ac)	Ha	(Ac)	Ha	(Ac)	Ha	(Ac)
Row crops	A1	7	(18)	.3	(.7)	998	(2,467)	1,390	(3,435)
Small grain	A2	223	(550)	8.4	(21)	5,811	(14,358)	7,971	(19,695)
Forage crops	A3	--	(--)	--	(--)	182	(450)	231	(571)
Grassland	A4	36	(90)	1.4	(3.5)	1,226	(3,030)	1,705	(4,212)
Retired land	A6	15	(37)	.6	(1.5)	27	(66)	49	(121)
Upland timber	TU	15	(37)	.6	(1.5)	423	(1,044)	638	(1,576)
Bottom-land timber	TB	2,181	(5,388)	82.9	(207)	3,776	(9,330)	10,676	(26,379)
Upland brush	BS	--	(--)	--	(--)	88	(219)	88	(219)
Oil land	OL	--	(--)	--	(--)	44	(108)	55	(137)
Water	WA	154	(380)	5.8	(14.5)	173	(428)	467	(1,155)
Totals		2,631	(6,500)	100	(250)	12,748	(31,500)	23,270	(57,500)

Because of high pelt values, minks and muskrats are heavily trapped. Raccoons are taken primarily by hunters. "Coon" hunting is a popular night sport. In general, hunters pursue the sport more for pleasure than for monetary gain although kills are usually pelted. The low pelt and recreational value of opossums has resulted in only incidental kills. Few terrestrial fur animals are trapped or hunted other than as predator control measures. A without-the-project fur-animal value amounts to \$1,900.

Post-impoundment conditions for furbearers were described separately for terrestrial fur animals and for aquatic fur animals, viz:

Terrestrial fur animals would suffer habitat losses similar to those stated for upland game. Small economic returns of long-haired furs, however, minimize the significance of the adverse effects of such habitat destruction. Low pelt prices reduce the incentive to harvest these animals. In view of this, the loss to the fur-animal resources is considered greater than that shown by the monetary evaluation.

It is believed that the Carlyle Reservoir would not provide optimum conditions for the production of aquatic fur animals. In spite of an increase in the suitable shoreline habitat, and perhaps a greater quantity of aquatic vegetation, oil and salt water discharges into the proposed reservoir would probably prevent any benefits from accruing to the aquatic fur animal resources within this area. If it could be assumed that pollution which exists today would be eliminated, the muskrat and mink total catch values would increase 25 and 10 percent, respectively. Detrimental factors such as bank erosion and water fluctuation would not allow a greater increase. The with-the-project value of \$1,600 is a slight decrease from the without-the-project fur animal harvest value. Elimination of pollution in the Carlyle Reservoir would raise the fur animal value by about \$200 annually, to correspond to the without-the-project value.

The fur animal values were calculated in much the same fashion as were the upland game values. Tables 5 and 6 contain the values computed by the Fish and Wildlife Service for the Carlyle Lake project area in circumstances either without or with the project, respectively.

Table 5. -- Fur animal values assigned by Fish and Wildlife Service for Carlyle project area without the project

Wildlife group and species	Type and area used		Approx. harvest per unit of habitat	Approx. total harvest	Unit value	Total value
	Cover type	Hs (Ac)				
Fur animals						
Muskrat	All types	23,720 (57,500)	1 per 150 acres	383	\$ 1.35	\$ 517.05
Mink	All types	23,720 (57,500)	1 per 723 acres	80	10.40	832.00
Raccoon	All types	23,720 (57,500)	1 per 500 acres	115	3.15	362.25 ^a
Skunk	All types	23,720 (57,500)	1 per 1,376 acres	42	1.40	58.80
Weasel	All types	23,720 (57,500)	1 per 21,333 acres	3	.72	2.16
Red fox	All types	23,720 (57,500)	1 per 3,000 acres	13	3.90	50.70 ^b
Gray fox	All types	23,720 (57,500)	1 per 4,000 acres	13	1.80	23.40 ^c
Opossum	All types	23,720 (57,500)	1 per 842 acres	19	.35	6.65 ^d
Total value						\$1,853.01

- a. Total yield pelted
b. 30.0% by hunter & 70% by trapper
c. 9.5% by hunter & 90.5% by trapper
d. 72% by hunter & 28% by trapper

Table 6 . -- Fur animal values projected by Fish and Wildlife Service for Carlyle project area with the project

Wildlife group and species	Type and area used		Approx. harvest per unit of habitat	Approx. total harvest	Unit value	Total value
	Cover type	Ha (Ac)				
Fur animals						
Muskrat	Lake shore	23,720 (57,500)	1 per 150 acres	383	\$ 1.35	\$ 517.05 ^a
Mink	Lake shore	23,720 (57,500)	1 per 723 acres	80	10.40	832.00 ^b
Raccoon	All types	13,149 (32,490)	1 per 500 acres	65	3.15	204.75 ^c
Skunk	All types	13,149 (32,490)	1 per 1,376 acres	24	1.40	33.60
Weasel	All types	13,149 (32,490)	1 per 21,333 acres	2	.72	1.44
Red fox	All types	13,149 (32,490)	1 per 3,000 acres	8	3.90	31.20 ^d
Gray fox	All types	13,149 (32,490)	1 per 4,000 acres	7	1.80	12.60 ^e
Opossum	All types	13,149 (32,490)	1 per 842 acres	11	.35	3.85 ^f
Total value						\$1,636.49

a. Approx. 25% increase

b. Approx. 10% increase

c. Total catch pelted

d. 30.0% by hunter & 70% by trapper

e. 9.5% by hunter & 90.5% by trapper

f. 72% by hunter & 28% by trapper

Waterfowl Resources -- Pre-impoundment Predictions

Waterfowl were considered to be the most important wildlife resources associated with the completed project. Planning for waterfowl resources was more intense due to this greater interest. As with other wildlife groups, the impact of the Carlyle project on waterfowl was first described in the FWS's 1954 planning report.

The Kaskaskia River attracted migratory waterfowl during spring and fall migrations prior to construction of the Carlyle project. The pre-project conditions were described as follows in the 1954 FWS report:

A segment of the waterfowl migrating north and south within the Mississippi Flyway pass inland over the State of Illinois. When the Kaskaskia River is out of its banks, many of these birds stop to feed and rest within the Carlyle Project area. The degree of waterfowl utilization depends on the concurrent time and duration of inundation and flight periods. Little use of the river by waterfowl occurs during normal water stages.

The spring and fall flights are predominantly mallards, although pintails, black ducks, wood ducks, baldpates, lesser scaups, blue-winged teals, green-winged teals, coots, and blue, snow, and Canada geese are included in the migration. Due to the frequency of spring flooding and the availability of floating mast and corn, both highly desired spring foods, the spring migration is larger than the fall flights. Mallards occasionally remain in the area during the winter months and a limited number have been reported nesting in the small slough areas. Although the numerous wood ducks produced in this locality rarely remain until the hunting season opens, their breeding value contributes to the economic importance of waterfowl in the Carlyle area. Geese seldom utilize the project area, and consequently are rarely taken by hunters. Since the fall hunting season rarely coincides with fall flooding, hunting success is sporadic. An annual value of \$4,700 is computed for the waterfowl use of the Carlyle Project area.

Construction of the project was expected to enhance waterfowl conditions if potential oil pollution problems were solved. The following three paragraphs contain the Service's 1954 waterfowl predictions:

Under optimum conditions, the Carlyle Reservoir would prove beneficial to waterfowl. Diving ducks as well as dabblers would utilize the project area during flight periods. Protected resting sites would be provided by the average annual minimum pool. Isolated spots within the expected shoal areas above mile 140 would produce some aquatic and semi-aquatic food desired by waterfowl. However, due to severe wave action caused by prevailing south winds, inflowing turbid waters, and oil and salt water discharges, the lake proper would produce little vegetation. Sufficient terrestrial food would be produced on the periphery of the basin to support field-feeding ducks and geese.

Wood duck habitat would be destroyed. It is expected, however, that mallards would nest on the margin of the reservoir to compensate for the wood duck loss. The future nesting value within the maximum flood control areas would be equivalent to that computed in formulating without-the-project values. An increased number of coots would utilize the cove areas during the flight periods, and a few might remain to nest in these areas. Snow, blue, and Canada geese would rest and feed within the flood control pool during the spring and fall. It is expected that Canada geese might use the impoundment as a wintering ground.

Polluted water conditions would eliminate the potential waterfowl usage of the proposed impoundment and conceivably could result in a loss to waterfowl. A continual build-up of industrial and oil pollutants would not only curtail growth of natural duck foods, but would also result in direct kill to waterfowl coming in contact with floating oil scum. A portion of the Kaskaskia River flight could be eliminated in this manner. Because of the intangibility of the facts, however, no loss is assigned to waterfowl. By the same token the lack of any solution to the anticipated oil pollution problem precludes the assumption that the proposed impoundment would benefit waterfowl. Therefore, the same value of \$4,700 is assigned to Carlyle Reservoir with the project as the same area without-the-project. A satisfactory solution, however, for the elimination of pollutants would increase the Carlyle Reservoir with-the-project value to \$9,500, almost a 100 percent increase.

Waterfowl values without-the-project and waterfowl predictions with-the-project were based upon actual use of the project area by ducks, geese, and coots. No consumptive (hunting) value was assigned in either pre- or post-impoundment valuations. Table 7 summarizes the waterfowl use and value assessments employed in the 1954 FWS report.

Table 7 . -- Waterfowl visitation data as predicted by FWS for 1954 planning report

	Ducks		Geese	
	No. days	Value/day	No. days	Value/day
Without project	1,033,980	\$.0045	\$4,652.91	Negligible
With project	1,597,730	\$.0045	\$7,189.78	Negligible
			231,600	\$.0089
				\$2,061.24

Table . -- (Continued)

	Coots		Total waterfowl	
	No. days	Value/day	No. days	Value/day
Without project	19,000	\$.0045	\$85.50	1,052,980
With project	46,500	\$.0045	\$209.25	1,875,830
				\$4,738.41
				\$9,460.27

A summary of the anticipated changes in wildlife values associated with the Carlyle project, as presented in 1954 by the FWS, is presented in Table 8.

The FWS recommended several specific actions to mitigate or compensate for wildlife losses. A conservation pool, as proposed by the construction agency, was heartily endorsed by the Service. This minimum pool was expected to be 2,631 ha (6,500 ac) at Carlyle. The FWS was also vitally interested in solving the potential oil and brine pollution problem peculiar to the project area, which included several abandoned and active oil wells. The Service requested action which would mitigate the wildlife losses associated with the project.

The 1954 FWS report contained several specific recommendations related to fish and wildlife. Those relating to the Carlyle project, as quoted in the CE's General Design Memorandum for the project (6), were:

- (1) Conservation pool be retained in the Carlyle Reservoir at elevation 429.5 feet m.s.l. No drawdowns below this elevation be made except for the purpose of maintaining minimum flows as described in recommendation No. 2.
- (2) Sustained minimum flow of 50 second-feet be maintained in the channel below Carlyle as planned by the Corps of Engineers.
- (3) Bottom waters be discharged from the reservoir as planned by the Corps of Engineers.
- (4) Prior to construction of the Carlyle Reservoir, the Federal, State, and private agencies involved in the oil problem agree upon a plan to effect remedial measures for the elimination of this pollution problem.
- (5) Consistent with the primary purposes of the impoundments, operations beneficial to fish and wildlife resources be included in the plans of operation for the reservoir.
- (6) Wherever feasible, the lands between the average annual maxi-

Table 8. -- Summary of wildlife values before and after construction of Carlyle project as related in 1954 FWS planning report (unpolluted figures only)

	Without the project	With the project (without oil pollution)	Difference	
			\$	%
Big game	\$ 800	\$ 270	- 530	-66.3
Upland game	\$22,600	\$11,700	-10,900	-48.2
Fur animals	\$ 1,900	\$ 1,800	- 100	- 5.3
Waterfowl	\$ 4,700	\$ 9,500	+ 4,800	+102.1
Total	\$30,000	\$23,270	- 6,730	- 22.4

sum pool and proposed "taking line" of the reservoir be managed by the State of Illinois for the purpose of developing and improving the amount of wildlife habitat.

(7) Tracts of land nearly surrounded by waters of the reservoir at flood-control pool level be acquired by the project planning agency and managed for the betterment of wildlife by the State of Illinois.

(8) Efforts be made to control bank erosion of the Carlyle Reservoir.

(9) Timber clearing above the permanent pools be restricted to flood intolerant trees and dead and dying timber. All timber, logs, and brush be removed within the limits of the navigation pools.

(10) All federally-owned land in the project area be opened to free use by the public except such portions as may be reserved by the project planning agency for purposes of safety, efficient operation, or protection of public property.

(11) Leases of federal land in the project areas stipulate the right of public access for the purpose of hunting, fishing, and other uncommercialized recreational purposes.

(12) Administration of project acquired lands for fish and wildlife should be in accordance with a general plan formulated pursuant to the requirements of "The Act of August 14, 1946 (60 Stat. 1080)."

The 1954 FWS report was appended as Appendix H of the Survey Report which was submitted to Congress on April 19, 1957 (5). The project was authorized by the Flood Control Act of July 3, 1958, on the basis of this favorable Survey Report.

The CE's assessments of the specific recommendations contained in the 1954 FWS report are presented below (6):

In general, the recommendations of the U.S. Fish and Wildlife Service are concurred in. Normally, no drawdowns would be made below the top of the inactive storage pool in the Carlyle reservoir. A minimum release of 50 c.f.s. from the reservoir is planned under the proposed method of operation. Normally, releases from the re-

servoir would be made through the sluices, except during flood periods when discharges from the sluice would be augmented by spillway releases. Oil wells in the Carlyle pool area would be raised, and necessary remedial measures to effect maximum control of oil pollution will be worked out with various Federal and State agencies and companies concerned prior to construction. The designation of areas of land to be set aside for wildlife would have to be coordinated by the Fish and Wildlife Service or appropriate State agency with the individual landowners. Consistent with the primary purposes of the impoundments, the reservoirs would be operated so as to provide maximum benefit to fish and wildlife resources. A master plan will be formulated and developed by the Corps of Engineers for the management of Government-owned lands within the reservoir. The plan will be fully coordinated with various State and Federal agencies having an interest. The majority of the areas suggested by the Fish and Wildlife Service for State management would be in the flowage-easement category with ownership remaining with the individual. It appears doubtful that State management would be practical in such areas. The plan of reservoir operation does not envisage rapid drawdowns which would accelerate bank erosion. The major portion of clearing will be confined to the areas below the permanent pool level. Flood intolerant trees and dead and dying timber will be removed. Under the present policy, primary emphasis will be placed upon public use of the reservoir areas. It is anticipated that the State of Illinois will prescribe hunting and fishing regulations. Suitable access points will be made available insofar as existing legislation and policy will permit. Administration of project acquired lands for fish and wildlife will be accomplished in accordance with the Act of 14 August 1946. While substantial benefit to the fishery of the basin would be realized, the project would result in some loss to wildlife resources of the watershed.

As project design proceeded, the construction agency set aside a large section of project property as a fish and game management area. By letter dated January 8, 1962 (13), the CE informed the FWS of current project planning:

The public access areas map is furnished to indicate areas which will not be available for fish and game management in the portion of the reservoir upstream from the Chicago, Burlington, and Quincy Railroad crossing. This whole area, in general, with the exception of the Tormalco and Patoka boat dock areas, will be available to the Illinois Department of Conservation for fish and game management purposes.

Land acquisition plans were specifically addressed in two succeeding para-

graphs in the same letter, viz:

This map has indicated on it the elevation 445 m.s.l. pool, which is top of the multiple-purpose pool, and the flood control pool, which is at elevation 462.5 m.s.l. The large-scale index map and the smaller-scale real estate map have, in addition to these two contours, a fee-taking line landward of which will be found the project boundary line. This limits the extent of flowage easement which it is planned to acquire.

The fee-taking line was the programmed five-year flood frequency elevation (Eisenhower purchase policy) or at elevation 137.2 m (450 ft) msl. The letter continued:

It is also desired to point out that completion of the acquisition program is scheduled roughly concurrent with completion of construction or during the period from July 1965 to the spring of 1966. Consequently, some minor revisions in the fee-taking line are to be expected. Wherever such changes should result in a slight reduction in area available for fish and game management, this will have to be tolerated. Wherever some additional acreage is acquired due to adjustments normal to implementation of good real estate procedures adjacent to lands designated for fish and wildlife management purposes, such additional lands will be made available to the Illinois Department of Conservation by minor boundary adjustments made at the local level.

A final statement from the CE's January 8, 1962 letter (13) related to interagency coordination during this planning phase:

Your expression of concern regarding the removal of timber by land-owners in areas proposed for waterfowl management is concurred in. Had the desires of the State of Illinois regarding retention of this timber been available early enough, it is believed that through some modification of the scheduling and the procedures of the real estate acquisition program, a plan could have been arranged which would have prevented this unfortunate situation. However, by the time the problem came to our attention, the real estate program had been pretty well crystalized, was underway, and could not be changed. It is hoped that the State of Illinois plans to purchase the timber on the land will result in minimizing of losses of desirable mast producing trees.

About the same time (17 days earlier), the Illinois Department of Conserva-

tion (IDC) sent the construction agency an engineering and feasibility report for sub-impoundments on the Carlyle project (8). The area proposed for sub-impoundment purposes consisted of 4,000 acres of project lands comprised of cropland and timber (primarily pinoaks). The proposed site was situated between elevation 444 msl and 450 msl. The anticipated development plan for this acreage was solely for waterfowl. A series of four separate pools established by a system of levees was proposed which would provide a combined surface area of 3,200 acres. The management plan envisioned by the IDC was described as follows:

The feasibility of the proposed Carlyle Reservoir Sub-impoundment is contingent primarily upon the availability of an adequate and dependable water supply at a reasonable cost. For proper management of the area consisting of pinoak timber and cultivated fields proposed to be planted with crops for waterfowl food, the area must be flooded at the end of the growing season and at a time when timber would not be killed due to inundation of the root crowns. This date has been established by biologists as October 1st. Flooding of the area should coincide with the opening of the waterfowl season which normally occurs around October 20th. This requires that the flooding of the area should be completed in approximately 20 days.

The method of supplying water to the proposed sub-impoundments was to pump from the reservoir. It was expected that this pumping operation would cost approximately \$4,000 annually and the development cost was estimated at \$80 per surface acre.

In January of 1962, the IDC sent to the CE their waterfowl management plans for the expected interim storage (433 ft msl) and for the eventual and current storage (445 ft msl). The management plan for the 445 ft msl pool provided for dividing the management area into three management zones -- one for intensive sub-impoundment development, one set aside as a no-hunting sanctuary, and one for undeveloped public hunting (9). The three lake

areas and proposed management strategies for each area, as described by the IDC, were as follows:

Area I

Approximately \$250,000.00 shall be invested on levee and pumping projects on this four-pool area comprising 3,180 acres. The single purpose is to provide better than average hunting in high quality food producing areas.

Area II

All of Area II falls within elevation 445 (normal pool). This refuge tract shall be approximately 3000 acres. There shall be no trespassing (fishing included) on the area from October 1 to January 1. This refuge will be posted by the Department.

Area III

Area III is in excess of 6000 acres and shall be open to public hunting under limited restrictions. It may be necessary to limit shooting hours, prohibit permanent blinds, restrict size of out-board motors, etc. However, by and large, every effort shall be made to keep this as "open territory," thus putting the duck hunter on his own. Boat traffic, other than by hunters, and fishing shall be prohibited in this area.

The foregoing waterfowl development report and management plan were incorporated by the CE as appendices to their Master Plan for the Carlyle project (10). The CE summarized their interpretation of the anticipated project impacts on wildlife in their initial Master Plan. These two brief paragraphs provide the essence:

(2) Game. Terrestrial small game animals found in the area include rabbit, squirrel, coon, and limited numbers of beaver and mink. There is an uncalculated deer herd existing; however, the numbers are not considered to necessitate a deer-hunting season. After the reservoir is placed in operation, and joint-use pool elevation of 445 is reached with Shelbyville in operation, it is anticipated that deer hunting opportunities will be greatly increased. It is hoped that the existing deer will be forced to seek higher grounds in search of improved browse and habitat that will obtain in the broad areas, which will receive intensive fish and wildlife management practices in the upper pool area above the CB&Q Railroad embankment.

(3) Waterfowl. Existing waterfowl resources found in the project area include ducks of a variety of species, and a limited number of geese. This resource is one which occurs primarily because of the location of the project area in relation to the Mississippi Flyway. The existing waterfowl resource is made up of migrating flocks and there are few instances of these flocks remaining in the project area the year round. Once the project is placed in operation and stabilized pool elevations are reached as a result of the Shelbyville project in operation, the extensive subimpoundment development planned by the Illinois Department of Conservation which will include a system of low levees, water outlet and pumping facilities, roads, and parking, is anticipated to attract larger numbers of these migrating waterfowl. This subimpoundment development will be utilized for refuge and shooting areas, production of wildlife foods such as millet, lespedeza, and sorghum, and is anticipated to produce a very promising waterfowl area.

The Master Plan summarized the project planning history and features anticipated for the purpose of wildlife management as follows:

20. FISH AND WILDLIFE AREAS

a. Selection of areas to be devoted to fish and game management resulted from a series of studies and continued coordinated planning effort of the U.S. Fish and Wildlife Service, the Illinois Department of Conservation, and the U.S. Army Engineers District, St. Louis, Missouri. The initial study was prepared by the U.S. Fish and Wildlife Service, Minneapolis Regional Office and was entitled "A Detailed Report on Fish and Wildlife Resources in Relation to the Flood Control Plan for the Kaskaskia River Basin, Illinois." The recommendations of this report, as well as those developed by later studies, will be implemented in the plan for maintenance and improvement of the fish and wildlife resources of the project area. All of the land lying in the north of the Chicago, Burlington and Quincy Railroad crossing, with the exception of two small operations, will be licensed to the Illinois Department of Conservation for fish and game management purposes. Fishing and hunting throughout the project area are permitted, with the exception of no hunting at public access areas and such other areas which the District Engineer may designate as required for operations.

The CE anticipated that hunter-use would approximate two-tenths of one percent of total visitations by 1970 at Carlyle, i.e., 3,000 hunter-days annually, of which 80 percent were expected to be by waterfowl hunters and

the remainder by squirrel and other upland game hunters. In June of 1963, the CE revised downward from 3,000 to 1,756 hunter-days their projected hunter-use estimate (14).

The FWS completed a draft General Plan for the project in March of 1966. Interestingly, in the memorandum (15) transmitting this draft field document to Washington, D.C. for review by the Directorate, the author referenced an earlier draft submitted four years earlier in which the FWS expressed an interest in Carlyle as a national waterfowl refuge, viz:

This draft supersedes the draft submitted to the Director March 23, 1962 in which we recommended that the area be declared of national significance for waterfowl. We have reviewed our previous report on the project and have discussed the management of the area with personnel of the Illinois Department of Conservation and the Corps of Engineers.

We believe that the area should be turned over to the Illinois Department of Conservation without a declaration of national significance to waterfowl but noting that it would have value to the program under the management of a cooperating agency.

There was considerable communication between the affected agencies in 1966 to facilitate implementation of the General Plan so that a license could be issued to the IDC at the earliest possible juncture. Early action was requested to allow the IDC to proceed with sub-impoundment development before the lake was flooded. The General Plan was executed in the spring of 1967.

Post-impoundment Wildlife Resources -- General Comments

The General Plan transferred some 6,346 ha (15,680 ac) under license to the IDC for wildlife management purposes. Included are some 3,035 ha (7,500 ac) of water and 3,100 ha (8,180 ac) of land at normal pool elevation. Ad-

ditional wildlife habitat is provided on undeveloped portions of the 979 ha (2,420 ac) land tract conveyed by the CE to the IDC for park purposes. The CE manages for wildlife approximately 419 ha (1,035 ac) on non-licensed lands owned by the CE. Flooding easements have been secured to an additional 10,143 ha (25,064 ac) contiguous to the project. In all (including flooding easement lands and state park property), the project impact area includes some 15,242 ha (47,664 ac) of potential habitat for terrestrial wildlife.

The majority of Carlyle's fee land is subject to annual inundation. The fee acquisition boundary was the 137.2 m (450 ft) msl contour while the currently programmed five-year flood frequency pool is the 138 m (453.2 ft) msl contour (3). According to the CE's Fish and Wildlife Management Plan (2), this limits wildlife potential of the project lands:

Floods often occur during April, May, and June which are the peak nesting periods for ground and low shrub nesting wildlife species. Production of wildlife within these nesting habitats is severely jeopardized.

Intensive wildlife management programs (especially for waterfowl) have been implemented since impoundment on appropriate areas of the fee acquisition lands, thereby greatly increasing the value of project lands for wildlife (including both game and non-game species).

Hunting and trapping are allowed in conformance with general state regulations on most project properties except in posted refuge areas within 500 feet of construction sites or developed recreation sites. Deer may be hunted only with bows on project lands lying South of the Burlington, Northern Railroad. All trappers must secure permits from the site superintendent.

Non-consumptive wildlife useage is encouraged at every opportunity.

Big Game -- Post-impoundment Occurrences

White-tailed deer constituted the only big game species originally found in the vicinity of the Carlyle Lake project. Although no site specific deer population estimates were available, hunting statistics collected annually by the IDC indicated the presence of a substantial number of deer and considerable hunting activity within the three-county area (Clinton, Fayette and Bond) contiguous to the project. Countywide hunting pressure (number of deer hunting permits sold), deer harvest and hunter success ratios continued to increase in all three counties following impoundment. Hunting pressure increased 48 percent, and the post-impoundment harvest (256 deer per year) was almost double the average of 130 deer per year harvested in pre-impoundment years (Table 9) in the three-county area. This rate of increase paralleled a similar pattern of increased deer hunting activity and harvest associated with expanding deer herds noted throughout southern Illinois during this same time frame (William J. Boyd, pers. comm., 1978). The annual average countywide deer harvest in Clinton County exhibited the smallest post-impoundment increase (37 percent) and Fayette County the largest (147 percent). The deer season in Bond County did not open until 1966, one year prior to the filling of the reservoir in 1967.

The area directly impacted by the Carlyle Lake project was considered to encompass approximately 25,293 ha (62,500 ac), including some 15,219 ha (37,600 ac) purchased in fee plus flooding easements obtained on 10,450 ha (25,823 ac) additional. Approximately 55 percent of the project lands were

Table 9 . -- Number of deer hunting permits issued, number of deer bagged, and hunter success (number of deer killed/permit) from Carlyle Lake project lands and contiguous counties, 1960-77

Year	Clinton County					Fayette County				
	Permits Issued (County)	No.	Harvest		Project lands No. % of killed total	Permits Issued (County)	Harvest		Project lands No. % of killed total	
			Total county	Success ratio			Total county	Success ratio		
1960	N.A.*	39	--	29	74	N.A.	30	--	0	0
1961	N.A.	97	--	N.A.	--	N.A.	30	--	2	7
1962	501	113	.23	64	57	504	53	.11	0	0
1963	N.A.	104	--	52	50	N.A.	36	--	3	8
1964	489	82	.17	31	38	465	53	.11	9	17
1965	471	72	.15	12	17	486	63	.13	11	17
1966	521	58	.11	11	19	495	66	.13	11	17
1967	555	62	.11	21	34	572	42	.07	13	31
1968	570	112	.20	25	22	577	63	.11	17	27
1969	521	76	.15	7	9	413	53	.13	2	4
1970	525	74	.14	12	16	420	72	.17	1	1
1971	526	87	.17	3	3	468	102	.22	7	7
1972	545	85	.16	13	15	502	75	.15	6	8
1973	582	139	.24	9	6	553	131	.24	3	2
1974	668	122	.20	4	3	672	144	.21	0	0
1975	930	163	.18	4	2	1,009	212	.21	3	1
1976	862	142	.16	6	4	802	161	.20	4	3
1977	806	163	.20	11	7	836	217	.26	7	3
Avg-1960-66	496	81	.16	33	43	488	47	.12	5.1	11
Avg-1967-77	645	111	.17	10	9	620	116	.19	5.7	5

* N.A. -- data not available; C.S. -- closed season in Bond County until 1966

Table 9 . -- (Continued)

Year	Bond County					Total				
	Permits Issued (County)	No.	Harvest		Project lands	Permits Issued (County)	No.	Harvest		Project lands
			Total county	Success ratio				Total county	Success ratio	
1960	C.S.*	--	--	--	--	N.A.	69	--	29	42
1961	C.S.	--	--	--	--	N.A.	127	--	N.A.	--
1962	C.S.	--	--	--	--	1,005	166	.17	64	39
1963	C.S.	--	--	--	--	N.A.	140	--	55	39
1964	C.S.	--	--	--	--	954	135	.14	40	30
1965	C.S.	--	--	--	--	957	135	.14	23	17
1966	120	13	.11	1	8	1,136	137	.12	23	17
1967	122	13	.11	0	0	1,249	117	.10	34	29
1968	141	13	.10	0	0	1,288	188	.15	42	22
1969	209	20	.10	1	5	1,143	149	.13	10	7
1970	212	27	.13	3	11	1,157	173	.15	16	9
1971	221	25	.11	0	0	1,215	214	.18	10	5
1972	230	25	.11	0	0	1,277	185	.14	19	10
1973	238	38	.16	0	0	1,373	308	.22	12	4
1974	247	23	.10	0	0	1,587	289	.18	4	1
1975	340	61	.18	1	2	2,279	436	.19	8	2
1976	289	40	.14	0	0	1,953	343	.18	10	3
1977	309	29	.10	0	0	1,951	409	.21	18	4
Avg-1960-66	20	2	.11	.2	8	1,013	130	.13	39	30
Avg-1967-77	233	29	.12	.5	2	1,497	256	.17	17	7

located in Clinton County, 40 percent in Fayette County, and 5 percent in Bond County (Table 10).

Deer harvest dynamics within the project impact area appeared to be governed primarily by the size of the pre-impoundment deer herd, the amount and quality of available deer habitat, reservoir clearing regimes, and hunter accessibility to project lands.

Although specific estimates of hunting pressure on lands impacted by the project were not available, the level of hunting pressure in pre-impoundment years was considered to be commensurate with general countywide statistics (Table 11). In later years, hunting pressure on project lands undoubtedly was more intense than in the surrounding counties because of greater hunter accessibility made possible by public land ownership and subsequent development of access facilities. It was possible, however, to estimate the number of deer harvested within the area of project impact, as hunters were required to report the location of each deer killed.

The 48 percent reduction of available wildlife habitat which occurred within the three-county area of project impact after the 1960-1963 pre-impoundment period appeared to be responsible for the overall 71 percent decline in deer harvest. This substantial reduction in deer harvest accrued entirely within the Clinton County sector of the project impact area. The Clinton County project area also experienced the greatest loss of deer habitat, some 58 percent, which consisted primarily of 6,249 ha (15,441 ac) of high quality bottom land hardwoods that were cleared during 1964-1966 (Table 12).

Table 10. -- Location, by county, and disposition of property acquired in conjunction with the Carlyle Reservoir project development

	Project land acquired			Ultimate disposition						Wildlife habitat remaining			
				Impounded ¹		Developed ²		Total					
	ha	ac	%	ha	ac	ha	ac	ha	ac	ha	ac	%	
Clinton Co.													
Fee	9,890	24,439	39	3,655	18,916	337	833	7,992	19,749	1,898	4,690	13	
Easement	3,930	9,711	16	--	--	--	--	--	--	3,930	9,711	27	
Total	13,820	34,150	55	3,655	18,916	337	833	7,992	19,749	5,828	14,401	40	
Fayette Co.													
Fee	4,629	11,439	18	2,616	6,464	--	--	2,616	6,464	2,013	4,975	14	
Easement	5,691	14,063	22	--	--	--	--	--	--	5,691	14,063	39	
Total	10,321	25,502	40	2,616	6,464	--	--	2,616	6,464	7,705	19,038	53	
Bond Co.													
Fee	635	1,568	3	251	620	--	--	251	620	384	948	3	
Easement	503	1,243	2	--	--	--	--	--	--	503	1,243	3	
Total	1,138	2,811	5	251	620	--	--	251	620	887	2,191	6	
Total													
Fee	15,154	37,446	60	10,522	26,000	337	833	10,859	26,833	4,295	10,613	30	
Easement	10,124	25,017	40	--	--	--	--	--	--	10,124	25,017	70	
Total	25,279	62,463 ³		10,522	26,000	337	833	10,859	26,833	14,419	35,630 ⁴		

1. Normal pool [26,000 acres at elevation 135.6 m (445 ft mal)]
2. Includes dam, spillway, buildings, picnic areas, campgrounds, access areas, etc.
3. Exclusive of 240 acres (fee) and 321 acres (flooded) acquired in Marion County
4. Exclusive of minor developments on lands licensed to IDC by CE

Table 11. -- Relationship of hunting pressure and habitat loss with deer harvest from project lands in Clinton, Bond, and Fayette Counties (data reflects average annual values for each time period specified). Carlyle Lake project, 1960-1977

	Clinton County			Fayette County			Bond County**			Total		
	1960-63	1964-66	1967-68	1969-77	1960-63	1964-66	1967-68	1969-77	1960-63	1964-66	1967-68	1969-77
Pressure												
No. Permits	501	494	562	663	504	482	575	631	C.S.*	40	132	255
% change		-1	+14	+18		-4	+19	+10			+70	+50
Cumulative %			+12	+32			+14	+25			+70	+538
Habitat Available												
Ac	13,821	5,828	5,828	5,828	6,274	6,274	7,705	6,410	1,138	1,123	887	887
% change												
Cumulative %												
Deer harvest												
Number	44	16	21	7	1.25	9.3	14	3	C.S.	0.33	0	0.6
% change		-64	+31	-67		+644	+51	-79			-	-
Cumulative %			-52	-84			+1,020	+140			-	-

* Deer hunting season closed until 1966

** Represents the 3,200 sub-impoundment area developed for waterfowl which is generally off limits for deer hunting

Table 12. -- Reservoir Basin clearing regimes in Clinton, Fayette and Bond Counties. Carlyle Reservoir project, 1964-1965

County	Total area impounded		Area cleared		Area uncleared*	
	ha	ac	ha	ac	ha	ac
Clinton	7,655	18,916	6,249	15,441	1,406	3,475
Fayette	2,616	6,464	0	0	2,616	6,464
Bond	251	620	15	36	236	584
Total	10,522	26,000	6,264	15,477	4,259	10,523

* Standing timber flooded

The critical importance of these bottomland hardwoods was underscored by the precipitous decline in deer harvest (64 percent) that occurred in Clinton County after clearing. The average annual harvest declined from 44 deer per year in 1960-1963 to only 16 deer per year during the following three years (1964-1966) when the clearing occurred. Concurrently, the deer harvest increased dramatically in 1964-1966 (644 percent) from the neighboring Fayette County project-impact sector containing some 3,642 ha (9,000 ac) of bottomland hardwoods that were left standing. Presumably, the increase noted in the Fayette County project-impact sector could be attributed to the influx of deer from the bottomland hardwoods in Clinton County when cleared.

The subsequent short-term recovery in deer harvested from Clinton County (up 31 percent from the 1964-1966 period), and the continued increased harvest noted in Fayette County (51 percent) during the immediate post-impoundment period (1967-68), may be attributed to temporarily increased concentrations of deer at higher elevations on contiguous project lands following impoundment. Improved hunter access and associated increased hunting pressure on project lands following impoundment also contributed to the increased harvest noted in 1967-1968.

Deer harvest declined substantially in later years (1969-77), reflecting reduced deer carrying capacity. This circumstance resulted from an extensive loss of high quality habitat due to impoundment and associated development of project lands. Continued high hunting pressure, which inhibited expansion of the deer herd, also contributed.

The average annual deer harvest from Clinton County project lands in the 1969-1977 period averaged only 7 deer per year, compared with 44 deer per year in the 1960-63 period. This 84 percent decline apparently reflected the reduced deer carrying capacity resulting from the extensive loss of high quality habitat (58%) following impoundment and associated development of project lands.

Although declining precipitously from immediate post-impoundment "bonus" harvest years (1967-1968) as occurred in Clinton County, the average annual deer harvest from project-impacted lands in Fayette County during the 1969-1977 period remained some 140 percent higher than during the 1960-1963 pre-impoundment period.

The relatively greater adverse impact of impoundment observed in Clinton County as compared to Fayette County can be explained, in part, by the relatively greater loss of deer habitat which occurred in Clinton County (58 percent as compared to only 25 percent in Fayette County). Another consideration, equally important, was the fact that the endemic pre-impoundment deer herd in the Clinton County area of project impact was obviously much larger (supporting an average annual harvest of some 44 animals as compared to only 1.25 deer per year in Fayette County), which magnified the scale of losses occasioned by the project in Clinton County. Also, the deer harvest within the immediate project impact area made up 43 percent of the total pre-impoundment countywide kill in Clinton County and only 11 percent in Fayette County. In post-impoundment years, the percentage of the countywide kill occurring within the immediate area of project impact

declined to 10 percent in Clinton County and 5 percent in Fayette County. Project impacts on deer harvest observed in Bond County were minimal due to the relatively small amount of land impacted by the project and the embryonic status of its pre-impoundment deer herd (hunting in Bond County was not allowed until 1966).

Upland Game Resources -- Post-impoundment Occurrences

The principal native upland game species occurring within the Carlyle Lake project vicinity included gray and fox squirrels, rabbit, mourning dove, raccoon, opossum, and quail. Ringneck pheasant were introduced following impoundment to provide put-and-take hunting.

Upland game habitat resources were impacted severely by the project. Impoundment and associated project developments preempted terrestrial wildlife habitat to the extent of approximately 72 percent, or some 10,859 ha (26,833 ac), of the total 14,992 ha (37,044 ac) project area acquired in fee. The full potential of the remaining fee-acquisition lands for upland game management, particularly quail and rabbit, was not realized because of frequent flooding. Upland game habitat located within the peripheral 10,124 ha (25,017 ac) flood-easement zone was also affected to a lesser, although substantial, degree by frequent flooding which killed mast producing trees and interfered with ground nesting activities.

Project impacts on squirrel habitat was especially severe, as clearing and subsequent impoundment of the 10,552 ha (26,000 ac) reservoir completely eliminated favored bottomland hardwoods located within the flood plain. Approximately 80 percent of the mast producing trees located in the 3,200-

acre subimpoundment area were killed by extensive and prolonged flooding which occurred during 1973 and 1974.

Although the principle management emphasis by IDC has been placed on waterfowl, some effort has been exerted to manage upland species on suitable areas of the 6,346 ha (15,680 ac) tract under license from the CE. Measures to improve food, cover, and hunter access for upland game species have been undertaken on some 931 ha (2,300 ac). Also, substantial undeveloped portions of the 979 ha (2,420 ac) of land licensed by the CE to the state for park purposes are utilized by upland game species to some extent. Squirrel, quail, rabbit, dove, and pheasant (put-and-take) hunting are permitted on special non-developed park areas. In addition, the IDC has recently purchased a 482 ha (1,191 ac) tract and has proposed the purchase of another 688 ha (1,700 ac) tract on the east side of the Kaskaskia River which will afford habitat for upland and forest game as well as for waterfowl (16).

Approximately 419 ha (1,035 ac) of CE-administered land, including unimproved forest, unimproved open areas, and cultivated lands, are managed principally to benefit upland game and forest species (17).

One 16 ha (40 ac) dove field has been developed by the IDC on CE-licensed lands. In 1977, the only year hunting data were collected, some 256 hunting trips were recorded. A total of 1,609 doves were bagged (William J. Boyd, pers. comm., 1978). Six additional dove fields are planned for future development. Two dove fields totalling 24 ha (59 ac) are managed by the CE. Over a four-year census period from 1974 to 1977, these fields

supported an annual average hunting pressure of 24 hunting trips which provided an annual harvest of 149 doves (18,19,20,21).

Post-impoundment harvest data for squirrels, rabbits, and quail on IDC management areas and on peripheral flood-easement lands were limited to sporadic hunter bag checks made by the IDC in 1977. It was estimated that 427 squirrel, 106 quail, and 148 rabbits were bagged during an estimated 2,270 hunting trips (William J. Boyd and Merrell Collins, pers. comm., 1978). The hunting activity occurred on suitable sites located throughout the project area, including the waterfowl sub-impoundment area, portions of Hazlet State Park open during the upland game hunting season, and flooding easement lands. It was estimated that hunting pressure and harvest of rabbits and quail on lands managed by the CE amounted to approximately 30 percent of the total harvest (32 quail and 44 rabbits) and hunting effort (680 trips) exerted on the larger state-controlled area. Squirrel hunting was considered negligible on CE-managed lands (James F. Gore, pers. comm., 1978). In addition, the IDC (Merrell Collins, pers. comm., 1978) estimated 720 night hunting trips resulted in a harvest of 353 raccoon and 7 opossum in 1977. An average of 4 fox (3 red and 1 grey fox) and 100 coyotes and/or coydogs are reported taken by hunters each year.

The IDC has since 1969 conducted controlled put-and-take pheasant hunts annually on a portion of the 2,420 acre Hazlet State Park which was leased to the State of Illinois by the CE. Hunting is permitted over a 30 day period extending from approximately mid-November to mid-December under a quota permit system which is designed to prevent overcrowding and promote

hunter safety. No hunting is allowed within 500 feet of designated recreational areas. Hundreds of hunters are turned away each year in order to stay within the prescribed quota. The permits are priced at \$5.00 each.

Hunters averaged some 4,988 trips to the area annually (1969 to 1977); they harvested 8,279 pheasants (1.66 pheasants/trip), amounting to 79 percent of the average annual stocking of 10,523 pheasants (Table 13). Hunting permit receipts (averaging \$24,943 annually) amounted to \$3.01 for each pheasant harvested or \$2.37 for each pheasant stocked (22). Rearing and delivery costs to the site are estimated (1976 estimate) at \$4.50 per pheasant stocked (William J. Boyd, pers. comm., 1978).

Fur Animal Resources -- Post-impoundment Occurrences

Raccoon, opossum, mink, muskrat, striped skunk, coyote and/or coydog, red fox, and grey fox have been identified in the vicinity of the Carlyle Lake project since impoundment. Mink, muskrat, opossum and raccoon are evidently abundant (1), viz:

The fur bearers are numerous throughout the area and one needs only navigate the area in a boat and note signs that are left by mink, muskrat, raccoon, and opossum.

However, current trapping for mink and muskrat is negligible because of the low prices (\$5.00 for muskrat pelts and even less for mink) which have prevailed in recent years. Estimates provided by the IDC (Merrell Collins, pers. comm., 1978) indicated an average annual trapping harvest of about 38 raccoon, 2 opossum, 9 red fox, and 2 grey fox. Most of the estimated 353 raccoon and 7 opossum taken by hunters in 1977 were also pelted. The

Table 13. -- Summary of IDC Pheasant Release Program at Hazlet State Park,
Carlyle Lake project, 1969-1977

Year	No. hunting trips	Pheasants harvested		Pheasants released		% released pheasants harvested
		No	No/trip	No	No/trip	
1969	5,156	9,436	1.8	11,808	2.3	79
1970	5,683	10,286	1.8	13,002	2.3	79
1971	5,450	8,021	1.5	10,845	2.0	73
1972	4,797	8,147	1.7	10,425	2.2	78
1973	3,665	6,100	1.7	7,535	2.1	81
1974	4,907	8,174	1.7	9,552	1.9	86
1975	5,063	8,365	1.7	10,946	2.2	76
1976	5,293	8,098	1.5	10,500	2.0	77
1977	4,879	7,880	1.6	10,090	2.1	78
AVG.	4,988	8,279	1.7	10,523	2.1	79

average pelt price received in the project vicinity in 1977 is estimated between \$12 and \$15 for raccoon, \$1.50 for opossum, \$40 to \$50 for red fox, and \$25 for coyotes and/or coydogs. The potential total value of all the pelts taken by hunters and trappers would amount to some \$7,745, based on the minimum price quotation per pelt.

Waterfowl Resources -- Post-impoundment Occurrences

Although apparently not anticipated at the time of submission of the 1954 FWS report, subsequent negotiations between the IDC, FWS, and CE culminated in comprehensive plans for intensive waterfowl management by the IDC on land made available by the CE. The principal development features of the plan included the construction of levees, drainage ditches, and water control structures and pumps to provide a series of subimpoundments that could be separately manipulated to maximize production and waterfowl utilization of food crops produced by agricultural methods and/or mast-producing trees within the subimpoundments. A total of 890 ha (2,200 ac) within the 1,295 ha (3,200 ac) subimpoundment area currently may be flooded upon demand, and planning for an additional 121 ha (300 ac) of subimpoundment is underway (23).

The mast-producing trees which occurred within the subimpoundments, principally 100-year-old burr oak, swamp white oak, and pin oak, were considered especially valuable. Other species (hickory, sycamore, cottonwood) provided excellent cover. Unfortunately, approximately 182 ha (450 ac) of the timber within the subimpoundments that were scheduled for management as "green tree" reservoirs were killed as a result of prolonged flooding during the growing seasons of 1973-1974 (24). Reservoir water levels

topped the subimpoundment levees, leaving the trees standing in 1 to 3 m (6 to 9 ft) of water throughout the spring and summer growing seasons. Long-range plans are now underway to replace the original trees with flood-resistant bald cypress (65 percent) and pin oak (35 percent) on two-thirds [121 ha (300 ac)] of the affected area. The remaining dead timber will be left undisturbed to provide for hunter cover and wood duck nesting sites, and to encourage habitat diversity through natural succession. Plantings will be alternated with undisturbed areas in 4 ha (10 ac) strips. A maximum of 8 ha (20 ac) have been scheduled for replanting with 1,942 seedlings per ha (4,800 per ac) each year, or as funds and personnel permit. Some 7,000 cypress seedlings were planted in the subimpoundments in 1976 (25).

Three hundred wood duck nesting boxes have been erected in approximately 444 ha (850 ac) of floodable timber present in the subimpoundments. Long-term goals include erecting one wood duck nesting box per acre. The flooded timber is expected, altogether, to support 4,800 to 6,000 ducklings annually (16).

Also, minor manipulations of reservoir level during the summer and fall have been utilized to improve habitat for waterfowl (also marsh and shore birds). The reservoir is drawn down gradually in July from elevation 445 msl to 444 msl to provide a narrow band of moist soil along the shoreline, in which millet and smart weeds proliferate. The water level is allowed to rise gradually, beginning in mid-September, so as to reach elevation 445.5 msl by the first of December.

Primarily as a result of intensive management by IDC, the Carlyle Lake project area is ranked as the single most important public waterfowl area in the State of Illinois (26).

In addition to the 1,295 ha (3,200 ac) peripheral subimpoundment area, approximately 7,284 ha (18,000 ac) of the reservoir, including 3,642 ha (9,000 ac) of flooded dead timber and 3,642 ha (9,000 ac) of open water, are available for waterfowl hunting. A 3,237 ha (8,000 ac) refuge of open water is located at the lower end of the reservoir.

Over a six-year post-impoundment period, 1972-1977, some 44,014 ducks (average of 7,336 per year) were bagged during a total of 53,542 hunting trips (average of 8,924 per year). Thus (Table 14), the average annual hunter success ratio was 0.82 ducks per trip (27,28,29,30,31).

Hunting pressure (10,308 trips), number of ducks bagged (11,223), and hunter success (1.09 birds/hunting trip) were highest in 1975. Values for hunting pressure (7,076 trips), number of ducks bagged (4,418), and hunter success (0.62 ducks/hunting trip) were lowest in 1974. The higher-than-average values in 1975 were attributed to an abundance of ducks utilizing the flyway and the favorable food, water, and weather conditions which prevailed generally within the state in 1975 (30). The higher average values for hunting pressure, ducks bagged, and hunter success in 1972, compared with 1973 and 1974, reflects the unfavorable conditions of flooding which prevailed in 1973 and 1974 which, in turn, prevented row cropping within the subimpoundments. Peak-day waterfowl usage at Carlyle Lake in 1972 was estimated at 240,000 birds, by comparison, peak-day usage in 1973

Table 14. -- Waterfowl hunter use, harvest and success at Carlyle Lake, 1972-1977

Year	Number of hunting trips	No. ducks bagged	Hunter success
1972	9,362	7,736	.83
1973	8,268	5,639	.68
1974	7,076	4,418	.62
1975	10,308	11,223	1.09
1976	7,511	5,781	.77
1977	11,017	9,217	.84
Total	53,542	44,014	.82
Annual Average	8,924	7,336	.82

was estimated to have been only 8,000 birds (28).

The overall importance to waterfowl hunting success of the row crops in the subimpoundments and flooded dead-timber areas is highlighted in Table 15.

Approximately 90 percent of the hunting effort (89.4 percent of the trips taken in 1972 and 90.1 percent in 1973) and harvest (86.5 percent of ducks bagged in 1972 and 92.9 percent in 1973) occurred in the subimpoundment and flooded dead-timber areas. Although managed primarily for ducks, project lands are also utilized by Canada geese during their spring and fall migrations. In 1977, an estimated 205 geese were bagged in about 400 man-days of hunting (William J. Boyd, pers. comm., 1978).

Post-impoundment waterfowl usage of the Carlyle Lake project has been substantial. An estimated 100,000 to 250,000 waterfowl (primarily ducks) visit the area from October to April each year, depending on food supplies and water areas (1). According to the IDC, waterfowl use of the subimpoundment area, alone, has been estimated between 4,800,000 and 5,000,000 waterfowl-use-days annually (23). Aerial waterfowl counts of the Carlyle Lake project have been taken by the Illinois Natural History Survey. These counts were provided for purposes of the current evaluation (Frank C. Bellrose, pers. comm., 1978). Counts were available during the equivalent of three yearly migratory seasons (fall-early winter/winter-spring). The actual (unexpanded) count data are presented in Table 16. Expansion of these counts to arrive at duck-day and goose-day estimates required weighting the average of each two consecutive aerial counts by the number of days

Table 15. -- Distribution of waterfowl hunters and harvest at each major hunting area at Carlyle Lake, 1972-1973

Area	Hunting trip		Ducks bagged		Hunter success	
	1972 No.	1973 No.	1972 No.	1973 No.	1972 %	1973 %
Subimpoundment	4,127	4,143	3,297	3,603	42.0	63.9
Flooded dead timber	4,244	3,345	3,490	1,635	44.5	29.0
Total	8,371	7,488	6,787	5,238	86.5	92.9
Open waters	991	780	1,062	401	13.5	7.1
Total	9,362	8,268	7,849	5,639	100	100
					1.07	.51
					.84	.68

Table 16. -- Available aerial waterfowl count data for the Carlyle Lake project area from 1975-1978

Date of count	Number of waterfowl recorded		
	Ducks	Geese	Coots
1975			
October 20	1,235	0	100
November 3	7,133	0	745
November 18	220,700	600	15,000
November 19	144,645	1,475	1,200
December 1	159,000	0	25,200
December 2	129,945	1,500	1,200
December 17	65,660	1,100	325
1976			
January 6	40,975	675	110
January 21	1,500	285	0
February 3	1,015	33,200	0
February 18	8,910	6,500	0
March 2	36,670	2,975	2,100
March 18	68,390	3,350	8,500
March 31	5,960	1,350	2,500
April 12	1,350	500	425
October 28	23,305	1,950	5,400
November 8	27,700	0	0
November 17	107,595	1,150	150
November 22	37,500	650	0
December 1	156,175	750	0
December 15	37,435	915	0
1977			
January 7	31,530	2,235	0
January 19	1,760	600	0
February 2	1,155	1,800	0
February 16	1,170	4,500	0
March 3	68,660	130,600	500
March 16	136,150	5,850	2,800
March 31	24,715	4,050	1,500
April 13	6,440	190	800
November 4	25,530	925	11,000
November 18	84,200	775	1,000
December 7	104,325	4,050	12
December 22	31,355	3,760	0
1978			
January 4	4,355	1,960	0
January 27	4,640	1,725	0
February 9	435	1,300	0
February 27	215	940	0
March 10	470	3,400	0
March 22	15,435	5,075	1,600
April 12	9,715	410	3,200

between those counts. This weighting process resulted in estimated average seasonal waterfowl-use levels of 6,890,000 duck-days, 1,090,000 goose-days, and 255,000 coot-days (Table 17).

Although adversely affected by the loss of nesting cavities in the bottom land timber which was cleared prior to impoundment, the installation of wood duck nesting boxes both in the intensively managed subimpoundment area and in areas of flooded standing timber at the upper end of the lake subsequently enhanced wood duck production above pre-impoundment levels. An experimental evaluation conducted from 1973 to 1977 on a 130 ha (321 ac) tract of flooded dead timber in the upper reaches of Carlyle Lake revealed that wooden nesting boxes were used much more extensively by wood ducks than metal nesting boxes (32). This study also indicated that nests placed on trees fronting open water were preferred over nests placed further back into the flooded timber. Approximately 1,000 mallard ducklings per year are produced within the project boundaries (Merrell Collins, pers. comm., 1977). Limited reproduction by blue-winged teal, also, has been documented within the project area (33).

Wildlife Resources -- Evaluation of Planning Input

The harvest data (number of animals) presented by the FWS in their 1954 basic data report (11) were based on arbitrary estimates of harvest per unit of habitat as provided by IDC personnel (Table 18). Differences between "without-the-project estimates" and "with-the-project predictions" were based strictly on the total amount of habitat expected to be lost as a result of project construction. No attempt was made to accommodate any influence on harvest that could be expected to result from possible dif-

Table 17. -- Expanded estimated number of duck-days, goose-days and coot-days for 1975-1978 at Carlyle Lake project

Period covered	Duck-days	Goose-days	Coot-days
Oct. 20-Dec. 31, 1975	6,129,850	47,076	318,214
Jan. 1-April 12 and Oct. 28-Dec. 31, 1976	6,402,275	757,356	219,339
Jan. 1-April 13 and Nov. 4-Dec. 31, 1977	7,546,706	2,233,663	167,504
Jan. 1-April 12, 1978	577,002	225,987	60,000

Table 18. -- Harvest per unit of habitat data utilized by the FWS in the 1954 Carlyle Lake Project Basic Data Report*

Species	No. animal per habitat unit	
White tailed deer	1/5,000 ac	(2,024 ha)
Squirrel	1/4 ac	(1.6 ha)
Rabbit	1/20 ac	(8.1 ha)
Quail	1/32 ac	(13 ha)
Raccoon	1/500 ac	(202 ha)
Red fox	1/3,000 ac	(1,214 ha)
Grey fox	1/4,000 ac	(1,619 ha)

* Harvest data was not employed for mourning doves or waterfowl. Instead, "use-day" data was presented. Computation as follows: Dove -- based on number of days residence on project assuming 3 adults per section and average production of 2.5 juveniles per adult. Wood duck use was computed on the basis of four breeding pairs per section with an average brood of 5. All other waterfowl computed on basis of estimated total number of days residence by each individual

ferences in land usage and/or hunter accessibility. At best, the data quoted in the 1954 FWS report reflects only estimates of potential harvest based on habitat carrying capacity rather than an empirical assessment of actual harvest. Thus, the value of any comparison of empirically collected post-impoundment data with such hypothetical data is extremely tenuous.

However, examination of pre-project (1960-1966) and post-project (1967-1977) deer harvest statistics collected by the IDC indicates that the 1954 FWS report underestimated the magnitude of the deer harvest for both pre-impoundment and post-impoundment periods. The average annual pre-impoundment (1960-1966) deer harvest was actually 39 deer, or 6.5 times greater than the harvest of six deer predicted in the 1954 FWS report. Also, the observed post-impoundment harvest averaged 17 deer per year, or 8.5 times more than the two deer predicted in the FWS report. It is noteworthy, while the magnitude of both the pre- and post-impoundment deer harvests was substantially underestimated, that the relative rate of decline in the deer harvest predicted in the FWS report (67 percent) was similar to the 56 percent decline that actually occurred.

Additionally, the 1954 FWS report stated that project construction could be expected to "greatly reduce the chance of success in developing a permanent deer herd in the Kaskaskia Basin." The 1954 report described the Basin as "an area of 5,840 square miles." This concern proved unwarranted. In fact, the average annual deer harvest in the three-county area contiguous to the project almost doubled after impoundment, increasing from 130 deer per year in pre-impoundment years to 256 per year following impound-

ment. This rate of increase paralleled a similar increase noted throughout southern Illinois during the same period. It seems clear that project impacts on deer resources were restricted to the immediate area of the project and appeared to be directly related to the amount of deer habitat lost due to impoundment and associated project development.

In contrast to the increased harvest noted for deer, the observed post-impoundment harvest (1977 IDC bag check) of most upland game species experienced a drastic decline in comparison with both the without-the-project estimates and post-impoundment predictions. The decline from without-the-project estimates provided in the 1954 FWS Basic Data Report (11) amounted to 94 percent for squirrel, 86 percent for rabbits, 84 percent for quail, 86 percent for opossum, and 43 percent for fox (Table 19). The 1954 FWS with-the-project predictions forecast a post-impoundment loss of some 61 percent for squirrels, 25 percent for rabbits and quail, and 43 percent for opossum and fox; in contrast, the harvest was observed (1977 bag check estimates) to decline by 84 percent for squirrels, 82 percent for rabbits, 79 percent for quail, and 75 percent for opossum. The estimated fox harvest was the same as predicted.

Waterfowl were expected to be the most important wildlife resource at the completed Carlyle project. Although the 1954 FWS report did not mention the subimpoundment concept, the authors did predict a significant increase in the use of the project area by waterfowl, pending solution of oil pollution problems. The project area was expected to support 1,598,000 duck-days, 232,000 goose-days and a total of 1,876,000 waterfowl use-days annually. This projection constituted a predicted use increase for the pro-

Table 19. -- Comparison of FWS "without-the-project estimates" of wildlife harvest and "with-the-project predictions" with observed 1977 post-impoundment occurrences estimated by the IDC

Species	"Without-the-project estimates"		"With-the-project predictions"		Post-impoundment occurrences		
	No.		No.	% change	No.	% change from FWS "without-the-project estimates"	% change from predicted value
Deer	6		2	-67	171	+183	+750
Squirrel	6,875		2,710	-61	427	- 94	- 84
Rabbit	1,419		1,059	-25	192	- 86	- 82
Quail	887		662	-25	138	- 84	- 79
Raccoon	78		46	-41	353	+353	+667
Opossum	49		28	-43	7	- 86	- 75
Fox	7		4	-43	4	- 43	0.0
Dove (use-days)	121,053		68,421	-43	N.A. ²	N.A.	N.A.
Dove (harvest)	Negligible		Negligible	--	1,758	+	+
Pheasant	None		None	--	8,279	+	+
Duck (use-days)	1,033,980		1,597,730	+55	6,890,000	+566	+331
Duck (harvest)	N.A.		N.A.	--	7,336 ³	N.A.	N.A.
Goose (use-days)	Negligible		231,600	+	1,090,000	+	+371
Goose (harvest)	N.A.		N.A.	--	205	N.A.	N.A.
Total waterfowl (use-days)	1,033,980		1,829,330	+77	7,980,000	+672	+336
Total waterfowl (harvest)	N.A.		N.A.	--	7,561	N.A.	N.A.

1. 1967-77 (average)
2. Not available
3. 1972-77 (average)

ject area of approximately 78 percent. The FWS expected a loss of wood duck habitat and nesting with a compensatory increase in mallard production. The FWS strongly supported the elimination of the oil pollution problems of the project area.

The IDC expressed an early interest in the Carlyle project as an opportunity to develop a system of controlled subimpoundments to attract migratory waterfowl. This was a state-funded development program on federally owned project lands. The IDC presented costs for this proposal but did not quantify the expected benefits either in duck-days or hunting activity.

The state's subimpoundment plans were implemented and, in spite of considerable damage as a result of flooding and the loss of the important mast-producing trees, the Carlyle subimpoundment area is the most important public waterfowl area in Illinois.

Current waterfowl use of the Carlyle management area is estimated at 6.9 million duck-days and 1.0 million goose-days, annually. These figures are 4.3 times greater than the levels predicted by the authors of the earliest planning report (1954).

Use of the entire Mississippi flyway has declined slightly for ducks and increased moderately for geese since Carlyle construction according to government data (34) (Table 20). The total number of nesting ducks in North America (35) has not changed significantly since the mid-1960s (Table 21). The dramatic increase in use of the Carlyle area by migratory waterfowl clearly reflects the enhanced habitat conditions created in association with the project. It should be noted that much of the observed increase

Table 20. -- Average annual waterfowl counts for Mississippi Flyway (includes Illinois); data tabulated for pre-Carlyle period (1960-1966) and for post-Carlyle period (1967-1978)

Period	Number of ducks	Number of geese	Number of coots
1960-1966	8,046,436	858,144	654,768
1967-1978	7,274,050	1,230,630	1,176,567
Percent change	-9.6	+43.4	+79.7

Table 21. -- Breeding population estimates for 10 species of ducks (in thousands); evaluated for period of record preceeding construction of Carlyle and for period following construction of Carlyle

Years	Mallard	Gadwall	American wigeon	Green-winged teal	Blue-winged teal	Northern shoveler	Pintail	Redhead	Canvas-back	Scaup Totals
1955-1966	8,877	1,263	3,079	1,879	5,171	1,756	6,152	619	567	6,409 35,772
1967-1977	8,606	1,658	3,102	2,114	5,096	2,016	6,122	736	582	7,062 37,120

in waterfowl usage and associated increased hunting opportunity following reservoir construction was of local benefit and primarily attributable to intensive waterfowl development and management activities concurrently undertaken by the IDC.

With the exception of the projected increase in on-site mallard and wood-duck production, most of the waterfowl usage was derived from migratory birds endemic to the Mississippi Flyway.

Planning for resident terrestrial wildlife mitigation was not adequate. The extremely restrictive land acquisition policy in effect when Carlyle was built severely limited development of compensatory facilities for the resident wildlife community. Compounding this problem was the miscalculation of storage-frequency probabilities by the construction agency. The land acquisition policy in effect during construction limited fee simple purchase to the five-year flood frequency elevation, which was expected to be the 137.1 m (450 ft) msl contour. The 137.1 m contour was therefore the upper permissible limit to land purchase. However, flood storage has been of greater magnitude than anticipated and the five-year flood frequency elevation is currently computed by the CE to be 138 m (453.2 ft) msl (3). The annual flood pool at Carlyle over the 11 year period of record is the 137.4 m (450.7 ft) contour.

The adversities created for the State's wildlife management program by the higher than expected water storage levels at Carlyle Lake have been further compounded by recent changes in the water management plan adopted by the CE. To accommodate increased commercial navigational use of the Kaskaskia

River below Carlyle Lake, the CE increased the minimum winter storage level from 134 m (440 ft) msl to 135 m (443 ft) msl. The loss of this already inadequate storage buffer (before the reservoir tops the waterfowl sub-impoundment dikes) further jeopardizes the IDC wildlife management program on the licensed Carlyle project lands.

There was no early indication that land acquisition for wildlife mitigation would receive support from the construction agency. In response to a very general approach to this subject by the FWS, the CE referred the FWS to the individual land owners. The conservation agencies decided to apply their limited resource development capability to the waterfowl sub-impoundment plan.

It should be noted that the CE has cooperated with most other FWS recommendations regarding fish and wildlife development at the Carlyle project. The CE bought the oil and gas rights to all of the lands purchased and capped the wells (some 69 wells were plugged) and the recovery of all minerals is prohibited. Standing timber was flooded, and the requested project lands were licensed under a general plan to the IDC.

FISHERY RESULTS AND DISCUSSION

Fishery Resources -- Pre-impoundment Predictions

The Kaskaskia River and associated bottomland lakes supported a diverse fishery prior to construction of the Carlyle project. The 1954 FWS report (4), described these resources as follows:

The Kaskaskia River and its bottom-land lakes within the project section supports a substantial fishing pressure. Fishermen regularly come to this area from as far away as St. Louis, Missouri, and Effingham, Illinois. Field investigations show that the areas of heavy clubhouse development coincide with the localities of heaviest fishing pressure. In the spring when waters are high and fish are moving to spawning habitat, net, trap, and trot-line fishermen appear in considerable numbers. Pressure is reduced in the early summer, but starting in July and continuing through September, a normal pressure pattern is maintained. The usual proportion of hook-and-line fishermen is 50 percent pole-and-line, and 50 percent trot-line. The use of traps and nets by individuals is heavy. It is common to find men fishing with traps, nets, trot-lines, and pole-and-line simultaneously. Fishes taken by non-commercial fishermen through the use of nets and traps are locally considered as obtained through sport fishing methods. Vocational commercial fishing is practiced by two or three men in the vicinity of Carlyle and Vandalia. Another eight or nine men fish the Kaskaskia waters with from 5 to 15 pieces of gear, but only as an avocation to augment their regular incomes.

Creel census studies indicate that the species which appear most frequently in the hook-and-line catch are carp, channel catfish, freshwater drum, bullheads, bluegills, bowfin, and bullalofishes. Trot-lines and traps primarily yield catfishes. Nets take carp, bullalofishes, and freshwater drum.

Several bottom-land lakes are heavily fished by plug casters and fly fishermen. This fishing occurs during and after mid-summer when the water has cleared and access is possible over the gumbo roads. Most of this effort is expended in fishing for largemouth black bass and panfish. Yield, in descending order of abundance, is composed of bluegills, bullheads, crappies, carp, sunfishes, gar, and largemouth black bass. No nets or traps are used in the oxbow lakes.

With the exception of heavier fishing pressure on the tributaries, the fishery factors of the section between Carlyle and New Athens are similar to those stated for the section which will be inundated by Carlyle Reservoir.

Pollution is extremely serious in the vicinity of the proposed Carlyle Reservoir area. Domestic sewage, manufacturing, and processing wastes are being closely watched by the Illinois Sanitary Water Board; satisfactory progress is being made toward the elimination of these few remaining pollution sources. However, oil field and coal mine wastes entering the streams continue to kill fish and destroy wildlife habitat. This disregard for resources belonging to the public, apparently condoned by many responsible persons, is of major concern to those agencies charged with the preservation of our waters, fish, and wildlife.

Based on creel studies conducted from 1948 through 1951, an annual value of \$10,000 is computed for the fishery of the 63 miles of main stem, the nursery values of the tributaries, and lakes within the average annual maximum pool limits of Carlyle Reservoir. A value of \$11,000 is computed for the fishery between Carlyle and New Athens. Below New Athens, the Kaskaskia River is affected by backwaters from the Mississippi River and has not been evaluated.

Post-impoundment conditions were presented for both Carlyle Reservoir and for the downstream section. A pollution-free monetary value of \$52,300 was predicted for the reservoir and \$12,000 for the downstream section. This entire discussion is presented in the following section:

The proposed reservoir would permanently inundate about 47 miles of the channel above the Carlyle Dam site. A lake of about 40 square miles at normal operating pool level (navigation pool stage) would be created. The resulting lake-type fishery would contain those species of fishes now present in the river. In spite of the turbid water which is expected to prevail and occasional fluctuations of reservoir levels during the spring, it seems probable that spawning success would be sufficient to provide varied year classes of fish in satisfactory numbers.

Turbid water and an annual fluctuation of about seven feet would hinder the growth of submerged aquatic plants. Shoreline vegetation such as cattail and bulrush would become established in the smaller coves which would offer protection to the young plants from wave action and bank erosion.

Conditions extremely injurious to the fishery of the reservoir could develop if steps are not taken to prevent salt-water wastes and oil from escaping into the reservoir and its feeder streams. Phenol, a component of oil, even in small proportions, imparts an unpalatable flavor and odor to the flesh of fish. It is probable that phenolic waters would eliminate the commercial fishery and greatly curtail sport fishing. In addition to oxygen reduction and the direct toxic effect of oil on fishes, the heavy resident tars of oil which blanket the bottom would kill all bottom life. The volatile oils would destroy surface organisms. Direct fishkill and disruption of the biological balance of the lake (e.g. the food chain) would result. Further fishery losses could occur from salt-water wastes.

The fishery of the river section below Carlyle would receive minor benefits through construction of the Carlyle Dam. The proposed minimum flow of 50 second-feet compares favorably with present minimum flows. Downstream flows would be stabilized and this reach of the river would be protected from floods. Assuming that bottom waters would be discharged, as provided in the plans of the Corps of Engineers, lower water temperatures would prevail immediately below the dam site. These factors would improve the environmental conditions in the downstream sector. Construction of the proposed levees and the few proposed pilot and diversion ditches would not significantly injure the downstream river fishery or alter existing oil-pollution conditions. However, the lake fishery of the downstream sector would be injured by the proposed construction. The shallow lakes lying behind the levees would neither receive initial spring flood waters nor natural restocking, and would probably lose their entire fishery value. The deeper lakes would retain a substantial proportion of their value, but due to the loss of natural restocking and possible lower water levels, some fishery loss could be expected. It is conceivable that club members would attempt management of these deeper waters. These lake-fishery losses would be offset by the aforementioned river fishery benefits.

A with-the-project annual value of \$19,300 is assigned to the fishery of the Carlyle Reservoir and other fisheries within the maximum pool area. If oil-pollution conditions within the reservoir could be prevented, this value could be raised to \$52,300. Downstream values are computed at \$11,000. It seems reasonable that this value could be raised to \$12,000 if industrial wastes could be excluded from the main-stem and tributary streams of this sector.

The fishery-related impacts of the Carlyle project were assigned a positive net value of \$42,300 annually to the reservoir and a \$1,000 net annual benefit to the downstream section of Kaskaskia River for a total net fishery benefit of \$43,300.

Translation of the dollar values contained in the 1954 report into some other quantity for which post-impoundment data were available, such as angler trips, was made possible by the eventual discovery of the basic data files in the FWS's Central Office in Washington, D.C. The basic data (36) allowed preparation of Table 22 which summarizes the pre-impoundment angling effort, harvest, and monetary value data for the Carlyle Lake site. Approximately 6,000 trips by recreational anglers and an associated fish harvest of 4,302 kg (9,484 lbs) were supported annually within this 105.3 km (62.2 mi) section of the Kaskaskia River and associated lakes. The harvest was valued (on the basis of angler expenditures) at 66¢ per pound for a total monetary value of \$6,259. Commercial fishermen harvested an additional 11,427 kg (25,191 lbs) of fish. Valued at 15¢ per pound, the total value of the commercial harvest was placed at \$3,779.

The downstream section of the Kaskaskia River was assigned an equal value per river mile (op. cit.), viz:

The reach of river between New Athens (Mile 40.9) and the Carlyle Dam site (Mile 106.8) is valued at the same rate as the Carlyle Reservoir, as the fishery and pressure factors are similar. A total of \$10,634.94 (\$11,000 rounded) is computed for this 65.9 mile reach.

Applying the proper conversions to this downstream value produced a hook-

Table 22. -- Pre-impoundment fishery data from Kaskaskia River within the 105.3 km (62.2 mi) Carlyle Lake site

	River			Lakes		
	Trips	Hours	Harvest kg	Value (lbs)	Trips	Hours
Pole and line	2,700	9,450	857.3	(1,890) \$1,247.40	600	3,480
Trot-line	2,700	40,500	2,939.3	(6,480) \$4,276.80	--	--
Hook-and-line totals	5,400	49,950	3,796.6	(8,370) \$5,524.20	600	3,480
Net and trap	89*	--	11,426.4	(25,191) \$3,778.65	--	--
Grand totals	--	--	15,223.0	(33,561) \$9,302.85	600	3,480

Table . -- (continued)

	Total			Value		
	Trips	Hours	Harvest kg	Value (lbs)	Trips	Hours
Pole and line	3,300	12,930	1,362.4	(3,003.6) \$ 1,982.38		
Trot-line	2,700	40,500	2,939.3	(6,480.0) \$ 4,276.80		
Hook-and-line totals	6,000	53,430	4,301.7	(9,483.6) \$ 6,259.18		
Net and trap	89*	--	11,426.4	(25,191.0) \$ 3,778.65		
Grand totals	--	--	15,728.1	(34,674.6) \$10,037.83**		

* Number of individuals involved

** Rounded to \$10,000

and-line angling estimate of 6,357 trips and an estimated harvest of 4,558 kg (10,048 lbs). The downstream commercial net and trap fishery was estimated at 12,106 kg (26,689 lbs) annually.

Post-impoundment predictions were developed on the basis of the average annual minimum pool (at elevation 134.2 m msl) of 7,892 ha (19,500 ac). The starting point for estimating the reservoir's probable post-impoundment value was extracted from the von Limbach curve (12). The curve, which plotted reservoir surface area vs. annual sport fishery value, provided a value of \$76,500 for a 7,892 ha (19,500 ac) pool. This value was considered too high, viz:

Due to water fluctuations and the resultant unsightly mud flats which would be exposed on the periphery of the reservoir, and recognizing the attraction the nearby Shelbyville Reservoir would have for non-local fishermen, a value of \$40,000 is assigned the Carlyle Reservoir. This value assumes oil free conditions within the Reservoir.

The total fishery value for the project area was placed at \$52,300, including a commercial fishing value of \$10,000 and a value of \$2,300 for the remaining stream fishing within the project boundary. The downstream river was assigned a value of \$12,000.

Precise conversion of these monetary values to harvest or man-day equivalents was not possible although the general magnitude of the post-impoundment angling effort was addressed in the following section from the basic data report:

It is difficult to forecast future fishery pressures. However, it is expected that sport fishing pressures would be five to six times as great as present pressures due to the increased water acreage available to the fishermen. Commercial fishing might double.

As the pre-impoundment recreational effort was placed at 6,000 angler-trips, the expected post-impoundment angling effort would have been in the area of 30,000 to 36,000 trips annually. Assuming the same value per pound as computed for the river fishery, the reservoir-supported sport harvest was probably expected to be around 29,000 kg (64,000 lbs) or 3.7 kg/ha (3.3 lbs/ac) based upon the 7,892 ha (19,500 ac) minimum pool. This results from dividing the total predicted sport harvest value of \$42,300 by 66¢ per pound.

Based upon the projected doubling of the commercial harvest, approximately 22,853 kg (50,382 lbs) was anticipated as the potential for commercial harvest.

Recreational and commercial fishing in the Kaskaskia River and associated ox-bow lakes below Carlyle were expected to remain essentially unchanged, with the improved quality and quantity of water in the river proper providing compensation for the fishery losses associated with the system of small riverside lakes. The actual monetary value assigned was \$12,000, which was nine percent above the value without the project. A calculated nine percent increase in sport fishing effort and resulting harvest produced figures of 6,929 angler trips and 4,968 kg (10,952 lbs), respectively, and a projected downstream commercial harvest of 13,196 kg (29,092 lbs).

Twelve recommendations were submitted to the construction agency to obtain the greatest benefits to the fishery resources and to minimize the

terrestrial wildlife damages. These recommendations and the CE response to each were incorporated in the Survey Report submitted to Congress. All 12 recommendations were presented in detail in the pre-impoundment wildlife section of this report (cf. pp. 19-21) and will not be repeated. However, several of the recommended actions addressed fishery-related matters, viz (abridged):

- (1) Maintain conservation pool at elevation 429.5 except for minimum-flow releases.
- (2) Release a minimum flow of 50 second-feet from the lake.
- (3) Reservoir discharge to be from near bottom.
- (4) Eliminate the oil pollution problem.
- (5) Operate reservoir to benefit fish community as consistent with primary project purposes.
- (6) Control bank erosion on lake.
- (7) Clear all timber from navigational pool.

A specific fish management plan was prepared by the IDC and submitted to the CE in 1961. This report (7) contained a plan to guarantee that adequate numbers of largemouth bass would be available for the initial stocking of Carlyle Lake. The plan was to use available ponds within the expected storage zone of Carlyle Lake as brood ponds. A summary of this state plan was presented in a CE file memo (37) as follows:

d. Fishery management. There exists old oxbow lakes throughout the reservoir area which will be inundated. Certain of these old lakes at the higher elevations have been selected. Resident populations are high in game fish but also include less desirable species such as carp, buffalo, and gar. The entire population of these selected lakes will be eliminated through the use of toxicants. After waiting the necessary period for

oxidation of these toxicants, these lakes will be stocked with largemouth bass fingerlings and some lakes with brood bass. During high water, these lakes will be protected from invasion by unwanted species by levees around the lake. Ultimately the bass population of these lakes will be released by the rising of reservoir water in the lakes' reservoirs. The object is to establish so large a population of largemouth bass as to protect this species from successful competition by less desirable species. The population of crappie, bluegill, and other panfish in the river will be sufficient to provide good fishing for these species without any stocking.

The CE's 1962 Master Plan projected 1970 angler-use of Carlyle Lake at 694,000 visitor-days (10). In 1963, the CE computed a new figure of 322,344 angler-days for 1970. The procedure for the updated projection was specifically detailed for Shelbyville and only summarized for Carlyle. The computations for both projects are presented below:

a. Shelbyville Reservoir, Kaskaskia River, Illinois.

Fishermen

19.8% of the 4,615,000 total annual visitors, or 913,770, will fish. They fish 10 trips, so $10 \times 913,770$ equals 9,137,700 fishing trips annually. It is estimated that 20% of these fishermen, or 1,827,540 will take 20% of their fishing day trips to Shelbyville, or 365,508 fishermen days. The warm water fishery benefit, value per fishing day, is \$.50 to \$1.50. We chose to use \$.75 which, when applied to the above fishermen days, gives a fishery benefit as of 1971 of \$274,131.

- b. Carlyle Reservoir, Kaskaskia River, Illinois. The methods of computation are identical to those used above and the same source of guidance was used as for computations for Shelbyville, so figures only are given.

Base year - 1970:

Fishermen

$19.8\% \times 4,070,000$ equals 805,860 fishing
 $10 \text{ trips} \times 805,860$ equals 8,058,600
 $20\% \times 8,058,600$ equals 1,611,720

20% x 1,611,720 equals 322,344 fishermen days
\$.75 x 322,344 equals \$241,758

Fishery Resources -- Post-impoundment Occurrences

The Carlyle project is operated to provide flood control, water supply, low-water flow augmentation, navigation, recreation, and fish and wild-life benefits. The project includes a minimum release of 50 cfs to the Kaskaskia River. The minimum discharge is released from elevation 127.1 m (417 ft) msl at a depth of 2.4 m (8 ft) msl below the tainter gate crest. When water releases are in excess of approximately 200 cfs, these releases are from the tainter gates which have a crest elevation of 425 ft msl -- 20 ft below the lake's surface at normal pool elevation.

The inactive pool contains $6.17 \times 10^7 \text{ m}^3$ (50,000 ac-ft) below elevation 130.9 m (429.5 ft) msl. The joint-use pool, which contains $2.87 \times 10^8 \text{ m}^3$ (233,000 ac-ft) is located between elevations 130.9 m and 135.6 m (445.0 ft) msl. The flood storage pool of $8.63 \times 10^8 \text{ m}^3$ (700,000 ac-ft) lies between 135.6 m and 141.0 m (462.5 ft) msl. A water-level management plan designed to concentrate the fish community in winter months was recommended by the IDC. The basic recommendation was to lower the normal pool from 135.6 m (445 ft) to 134.1 m (440 ft) msl after the duck season, and to reflood to normal pool during the spring. Additionally, IDC personnel requested that about once in five years the pool be lowered to at least 133.5 m (438 ft) msl. Accordingly, the lake was lowered to a minimum elevation of 134.1 m (440 ft) by the CE each winter from 1971 to 1977. However, during the winter of 1977-1978, the CE raised the winter pool

minimum elevation to 135 m (443 ft) msl to provide additional storage for accommodating increased commercial navigational use of the Kaskaskia River below Carlyle Reservoir.

Many formal access areas have been developed at Carlyle; 16 boat launching lanes have been developed on CE management areas and there are 17 launching lanes on the IDC management area (3).

Water quality at Carlyle is sufficiently high to permit direct-contact recreational activities. Some problems do exist, including high turbidity resulting from erosion on the watershed and lake-shore erosion. This wind-caused shoreline erosion has necessitated acquisition of additional lands and placing rip-rap along several particularly vulnerable shorelines. In 1975, analyses of certain commercially harvested fish species (bigmouth buffalo, smallmouth buffalo, river carpsuckers, and flathead catfish) revealed dieldrin concentrations in excess of Food and Drug Administration standards. Game fish were not found to be contaminated (38). Dieldrin, an agricultural herbicide, was banned in 1974 and this problem apparently has been controlled as commercial fishing was again permitted in 1978.

Carlyle Lake may become weakly stratified during the summer and dissolved oxygen occasionally disappears below 3.5 to 4.5 m (12-15 ft) (1). Such periods of stratification are of short duration and readily disrupted by wave action. Water quality conditions in the Kaskaskia River below the dam have improved since impoundment of Carlyle Lake. The Carlyle out-

flow carries less suspended sediment than the inflow. Water quality above Carlyle has also been enhanced by the upstream Shelbyville project.

The IDC and the CE cooperatively constructed a 2 ha (5 ac) nursery pond at Carlyle (Arnold Fritz, pers. comm., 1978). The pond was constructed to enable rearing of selected predator fish species to larger size prior to releasing them into the lake. The pond was used to rear largemouth bass fingerlings in 1976 (39). Construction of up to four additional ponds are desired at the project (2).

Within the 6,346 ha (15,680 ac) area under license to the IDC, 3,642 ha (9,000 ac) at normal pool 365.6 m (445 ft msl) are flooded dead timber. Boat lanes of 30 m (100 ft) width were cleared within this area (Richard Cameron, pers. comm., 1977). This area is used heavily by anglers.

Considerable emphasis has been placed on studies of the aquatic communities associated with the Carlyle project. The original fish community of the lake developed from the fish community which existed in the Kaskaskia River tributaries and adjacent bottomland lakes and ponds that were flooded when the lake was impounded. Also, in the year (1965) prior to impoundment, these bottomland lakes were stocked with 43,467 largemouth bass fingerlings. Approximately 1.5 million additional bass fry were planted in the impounding waters in 1966. Channel catfish were stocked in limited quantities in 1965 and white bass adults (totalling 3,634 fish) were planted on three occasions between 1965 and 1971. Fry of walleye and northern pike have also been stocked at Carlyle (Table 23).

Table 23. -- Stocking records for Carlyle Lake

Species	Number stocked	Year stocked	Size
Largemouth bass	43,467	1965	fingerling
	1,426,000	1966	fry
	55,000	1976	fingerling
	166,000	1977	fingerling
Channel catfish	4,675	1965	fingerling
White bass	1,369	1965	adult
	730	1966	adult
	1,535	1971	adult
Walleye	640,000	1974	fry
	1,828,000	1975	fry
	700,000	1976	fry
	880,000	1977	fry
Northern pike	1,035,000	1977	fry

Fingernail clams were introduced in an attempt to provide an additional food source for waterfowl and certain fish species including the freshwater drum (2).

Sampling of both young-of-the-year and older components of the fish population is conducted each year at Carlyle. The resulting data have identified population trends among the several harvested species of the Carlyle Lake fish community. One finding is that largemouth bass have experienced limited spawning success since lake impoundment. According to the CE, water-level fluctuation dramatically affects the reproductive success of certain important game fish species. The following quotation from the CE's revised Master Plan (3) addresses the subject:

The primary limiting factor of fish populations, particularly black bass and sunfish, is pool fluctuation during the spring spawning period. Spring water levels in Carlyle Lake fluctuate frequently and often abruptly, as a result of normal flood control uses. This is generally detrimental to bass and sunfish which typically spawn in shallow water along the shore. Rapidly falling water strands nests, and rapidly rising water often causes nest abandonment. For best management, pool fluctuations should not be permitted during the late spring (generally May and June). If the pool must be raised or lowered during this period the change should be no more than 0.1 foot per day.

This record of frequent spawning failure precipitated the nursery pond experimentation discussed previously. The white bass population, currently of great importance, was slow to develop at Carlyle. The first successful spawning season for white bass was in 1974. Establishment of the white bass fishery is currently considered to be one of the most successful management efforts undertaken to date (39). Black crappie and white crappie populations expanded quickly (white crappie dominant) and apparent-

ly peaked in the early 1970's. Reproductive success for both species declined sharply in succeeding years. Other sunfish populations appear to have stabilized or are declining slightly. Bluegill produce moderate year classes in most spawning seasons. Several commercial species exist in significant numbers in Carlyle Lake. Among the most important are bigmouth buffalo, smallmouth buffalo, river carpsucker, and carp. Gizzard shad is the most abundant species occurring in the lake, and commonly spawns two or three times each summer. Several important catfish species populate the lake. Both yellow bullheads and black bullheads constituted important segments of the fish community shortly after lake impoundment, but have since declined to minor importance. Both channel catfish and flathead catfish populations have stabilized at relatively important levels. Saugers continue to be taken from the lake but are not significant components of the fish community. Walleyes, as discussed previously, have been stocked for several years although the numbers planted have not been as high as believed necessary to establish a productive reservoir fishery (39). Freshwater drum are numerous and reproduce successfully. Their small size and poor condition are believed to reflect an inadequate food base for this species. A complete list of fish species known to inhabit Carlyle Lake is presented in Table 24.

Occasionally fish mortalities have occurred at Carlyle, including die-off of gizzard shad each spring. In 1976, the spring fish kill affected several species in addition to gizzard shad. The large kill in 1976 was due to an outbreak of the bacterial disease, hemorrhagic septicemia. Giz-

Table 24. -- List of fish species collected from Carlyle Lake and tailwaters (from Fish and Wildlife Management Plan, Appendix D to Master Plan)

Common name	Scientific name
Black bullhead	<u>Ictalurus melas</u>
Channel catfish	<u>Ictalurus punctatus</u>
Flathead catfish	<u>Plodictis olivaris</u>
White catfish	<u>Ictalurus catus</u>
Yellow bullhead	<u>Ictalurus natalis</u>
White bass	<u>Roccus chrysops</u>
Yellow bass	<u>Roccus mississippiensis</u>
Bluegill	<u>Lepomis macrochirus</u>
Black crappie	<u>Pomoxis nigromaculatus</u>
White crappie	<u>Pomoxis annularis</u>
Green sunfish	<u>Lepomis cyanellus</u>
Largemouth bass	<u>Micropterus salmoides</u>
Long-ear sunfish	<u>Lepomis megalotis</u>
Orange-spotted sunfish	<u>Lepomis humilis</u>
Red-ear sunfish	<u>Lepomis microlophus</u>
Bigmouth buffalo	<u>Ictiobus cyprinellus</u>
Black buffalo	<u>Ictiobus niger</u>
Golden redhorse*	<u>Moxostoma erythrurum</u>
Northern redhorse	<u>Moxostoma macrolepidotum</u>
Quillback	<u>Carpiodes cyprinus</u>
River carpsucker	<u>Carpiodes carpio</u>
Smallmouth buffalo	<u>Ictiobus bubalus</u>
White sucker	<u>Catostomus commersoni</u>
Blackstripe topminnow	<u>Fundulus notatus</u>
Bluntnose minnow	<u>Pimephales notatus</u>
Brook silversides	<u>Labidesthes sicculus</u>
Carp	<u>Cyprinus carpio</u>
Golden shiner	<u>Notemigonus crysoleucas</u>
Johnny darter	<u>Etheostoma nigrum</u>
Mosquito fish	<u>Gambusia affinis</u>
Red shiner	<u>Notropis lutrensis</u>
Sand shiner	<u>Notropis stramineus</u>
Silvery minnow	<u>Hybognathus nuchalis</u>
Grass pickerel	<u>Esox americanus vermiculatus</u>
Sauger	<u>Stizostedion canadense</u>
Walleye	<u>Stizostedion vitreum vitreum</u>
Freshwater drum	<u>Aplodinotus grunniens</u>
Goldeye	<u>Hiodon alosoides</u>
Skipjack herring*	<u>Alosa chrysocloris</u>
American eel*	<u>Anguilla rostrata</u>
Shortnose gar	<u>Lepisosteus platostomus</u>
Bowfin	<u>Amia calva</u>
Gizzard shad	<u>Dorosoma cepedianum</u>
Paddlefish*	<u>Polyodon spathula</u>

* Only reported from tailwaters of Carlyle Dam

zard shad are also infested with a microsporidian (Plistophora cepedianae). Other diseases and parasitic infestations have occurred at Carlyle. Largemouth bass and crappies are host to liver parasites which have been suspected of contributing to the poor reproductive success of these species.

In 1973, the IDC Reservoir Fishery Biologist for Carlyle described the recreational fishery provided by the lake as follows (40):

Carlyle Lake, a 26,000 acre U.S. Army Corps of Engineers Reservoir, is one of the most important recreational resources in southern Illinois. It's acclaim as a fine sport fishing lake is known statewide, as well as by Eastern Missouri anglers. As determined by the study "1970 Economic Survey of Daily Expenditures made by Carlyle Lake and Tailwater Anglers," the sport fishery value of this lake approaches three-quarters of a million dollars or more annually.

In addition to the economic study, post-impoundment creel surveys were conducted each year from 1966 through 1971, except for 1970.

The expanded results of these surveys were summarized in a 1971 IDC report (41). These data have been used to prepare Table 25 which presents the annual effort and harvest for the four fishing seasons surveyed. The statistics reveal that, by the end of the study period, approximately 129,000 angler-trips, or some 12.3 trips/ha (5 trips/acre), were recorded at the Carlyle complex each year. Harvest varied widely from year to year in the tailwater but remained relatively constant from the reservoir proper. During the last two years of the study (1969 and 1971), the sport catch averaged approximately 500,000 fish weighing almost 144,000 kg (317,000 lbs) -- an average harvest of 13.7 kg/ha (12.21 lbs/ac). Species composition of the catch for each year of the survey is summarized

Table 25. -- (Continued)

	1969			1971		
	Lake	Tailwater	Total	Lake	Tailwater	Total
No. fishermen	70,368	58,164	128,532	82,302	46,352	128,654
No. fishermen hours	371,368	336,160	707,528	368,738	189,605	558,343
No. fish caught	344,116	283,402	627,518	265,959	109,902	375,861
Wt. fish caught						
(kg)	81,090	72,643	153,733	79,473	54,635	134,108
(lbs)	178,770	160,148	338,918	175,204	120,448	295,652

for the reservoir in Table 26, and for the tailrace in Table 27.

Unfortunately, certain segments of the recreational fishery were not included in these surveys. Important omissions included all angling effort occurring between November and March, night angling (between 8:00 p.m. and 6:00 a.m.), and the trotline fishermen. An additional 25,000 to 50,000 angler-days, missed by surveys, are believed probably attributable to those factors (Arnold Fritz, pers. comm., 1977). The actual total angling effort would thus have ranged between 154,000 and 179,000 angler-days. Following the last survey (1971), angling effort remained relatively constant up to 1975, perhaps with a five percent increase (162,000-188,000 man-days). At that time, crappie fishing declined precipitously; adversely influenced by the low water in 1976 and the dieldrin problem in non-game fish, angling effort probably declined by as much as 10 percent from the 1975 level. In 1977, angling effort rose again to the 1975 level (Arnold Fritz, pers. comm, 1977). An approximation of current angling effort would therefore be on the order of 162,000 to 188,000 angler-days annually (15-18 trip/ha or 6-7 trips/ac). Assuming that anglers not censused at Carlyle were approximately as successful as those censused (1.12 kg/trip), the current harvest would be between 181,300 and 210,560 kg (400,000 lbs-465,000 lbs) equivalent to about 17-20 kg/ha (15-18 lbs/ac).

Fishing in the Kaskaskia River above Carlyle Lake has been improved since the lake was built according to local sources (1), viz:

Upstream and downstream fishing has been affected by the Carlyle Lake Project. Although not documented by studies, reports received by the Reservoir Fisheries Biologist and Department of Conservation Officers indicate that the stream fishing above

Table 26. -- Estimated total sport fishery catch in number and weight for Carlyle Lake from 1966 through 1969 and 1971

Species	1966		1967		1968	
	Number	Weight kg (lbs)	Number	Weight kg (lbs)	Number	Weight kg (lbs)
Largemouth bass	76	14 (31)	6,540	2,284 (5,036)	24,163	13,810 (30,445)
Bluegill	31	3 (6)	4,974	519 (1,144)	28,616	3,375 (7,440)
Other sunfish ¹	73	6 (14)	12,308	739 (1,630)	19,512	1,604 (3,537)
Crappie ²	--	--	2,537	633 (1,395)	41,175	7,658 (16,882)
Bullheads ³	52	10 (21)	45,444	6,391 (14,088)	104,558	20,394 (44,960)
Channel catfish	343	60 (130)	2,284	694 (1,530)	2,590	1,210 (2,668)
Flathead catfish	48	20 (43)	27	12 (27)	54	31 (68)
Yellow & white bass	--	--	--	--	--	--
Sauger & walleye	--	--	--	--	--	--
Carp	1,397	645 (1,425)	19,757	7,080 (15,608)	47,154	40,211 (88,650)
Buffalo ⁴	--	--	26	12 (26)	26	12 (26)
Freshwater drum	68	34 (74)	5,917	1,503 (3,314)	11,347	3,500 (7,716)
Bowfin	24	5 (12)	1,794	960 (2,117)	2,330	1,585 (3,495)
Others ⁵	--	--	27	9 (20)	127	34 (74)
Totals	2,112	797 (1,756)	101,635	20,836 (45,935)	281,652	93,424 (205,961)

¹ Flathead catfish
² Yellow & white bass
³ Sauger & walleye
⁴ Carp
⁵ Buffalo

Table 26. -- (Continued)

Species	1969		1971	
	Number	Weight kg (lbs)	Number	Weight kg (lbs)
Largemouth bass	18,573	5,560 (12,258)	35,093	10,983 (24,214)
Bluegill	51,825	5,172 (11,402)	18,349	2,331 (5,138)
Other sunfish ¹	9,011	601 (1,324)	1,311	111 (244)
Crappie ²	116,426	21,652 (47,735)	132,670	33,700 (74,295)
Bullheads ³	88,224	22,410 (49,405)	12,192	3,042 (6,706)
Channel Catfish	3,269	1,957 (4,315)	15,387	6,701 (14,772)
Flathead catfish	69	83 (182)	106	127 (279)
Yellow & white bass	159	18 (40)	9,837	1,605 (3,541)
Sauger & walleye	--	--	97	55 (121)
Carp	34,723	17,483 (38,543)	12,989	8,661 (19,094)
Buffalo ⁴	54	37 (81)	320	305 (672)
Freshwater drum	20,388	4,901 (10,805)	25,238	9,502 (20,948)
Bowfin	1,306	1,185 (2,612)	1,910	2,296 (5,062)
Others ⁵	89	31 (68)	460	54 (118)
Totals	334,116	81,090 (178,770)	265,959	79,473 (175,204)

1. Includes green sunfish, warmouth, redear, longear, orangespotted and hybrid sunfishes

2. Includes black and white crappies

2. Includes black and yellow bullheads

4. Includes smallmouth and bigmouth buffalo

5. Includes shortnose gar, quillback, river carpsucker, white sucker, northern redbreast, grass pickerel, goldenshiner and creek chub

Table 27. -- Estimated total sport fishery catch in number and weight for the Carlyle tailwater from 1966 through 1969 and 1971

Species	1966		1967		1968	
	Number	Weight (lbs)	Number	Weight (lbs)	Number	Weight (lbs)
Largemouth bass	669	124	7,060	2,114	8,874	5,112
Bluegill	628	57	4,315	372	18,831	1,965
Other sunfish ¹	757	65	5,327	427	11,540	874
Crappies ²	1,765	256	6,293	1,399	32,977	4,936
Bullheads ³	878	163	5,088	1,039	26,325	5,015
Channel catfish	754	246	2,993	909	21,084	6,695
Flathead catfish	114	47	119	34	146	66
White catfish ⁴	--	--	--	--	42	8
Yellow & white bass	78	21	625	108	322	45
Sauger & walleye	14	8	40	36	63	57
Carp	11,870	14,699	19,987	13,146	243,783	121,638
Buffalo ⁵	531	515	472	366	4,512	3,725
Freshwater drum	1,856	919	8,795	3,989	52,708	15,779
Bowfin	45	10	1,759	1,061	3,344	2,988
Others ⁶	105	31	352	100	910	337
Totals	20,064	17,161	63,225	25,100	425,461	169,240
		(37,834)		(55,337)		(373,105)

Table 27. -- (Continued)

Species	1969		1971	
	Number	Weight kg (lbs)	Number	Weight kg (lbs)
Largemouth bass	5,523	2,806 (6,186)	1,188	372 (820)
Bluegill	33,785	3,372 (7,433)	2,186	278 (612)
Other sunfish ¹	8,336	529 (1,167)	138	10 (23)
Crappies ²	64,097	9,595 (21,152)	11,795	2,996 (6,605)
Bullheads ³	28,552	5,439 (11,991)	4,387	955 (2,106)
Channel catfish	10,554	2,681 (5,911)	10,971	4,976 (10,971)
Flathead catfish	23	10 (23)	88	100 (220)
White catfish ⁴	--	--	--	--
Yellow & white bass	183	33 (73)	1,499	238 (525)
Sauger & walleye	77	44 (96)	391	427 (942)
Carp	74,339	31,023 (68,392)	52,473	33,799 (74,512)
Buffalo ⁵	1,016	1,018 (2,245)	4,848	4,618 (10,181)
Freshwater drum	51,681	8,908 (19,639)	18,068	4,590 (10,118)
Bowfin	4,558	6,885 (15,178)	864	1,039 (2,290)
Others ⁶	678	300 (662)	1,006	237 (523)
Totals	283,402	72,643 (160,148)	109,902	54,635 (120,448)

1. Includes warmouth, redear, longear, orangespotted, and hybrid sunfishes

2. Includes black and white crappies

3. Includes black and yellow bullheads

4. White catfish were observed in the trot-line catches but not the anglers catches

5. Includes smallmouth, bigmouth and black buffalo

6. Includes shortnose gar, goldeye, mooneye, skipjack, golden shiner, quill back, river carpsucker, white sucker, blue sucker, northern redhorse, golden redhorse, grass pickerel, American eel, and paddlefish

Carlyle Lake has been enhanced greatly. The downstream tailwater portion of the project has improved fishing also. Based on man-hours of use per acre of water, the tailwater area is the most heavily used at Carlyle.

An economic study of the recreational fishery at Carlyle was conducted by the IDC in 1970 (42). This study resulted in computed average daily expenditure values of \$5.31 per tailwater angler-trip and \$4.66 per reservoir angler-trip. When averaged, the daily expenditure (\$5.05) was almost identical to the value (\$4.98) reported in the 1965 National Survey of Hunting and Fishing according to the IDC report (op. cit.). Applying the average trip value of \$5.05 to the total annual fishing pressure of 162,000 to 188,000 angler-trips (assumes that expenditures by non-surveyed winter and night-time anglers are the same as those by surveyed anglers), provides a total monetary value of \$818,000 to \$950,000 for 1977.

Carlyle Lake also supports a commercial fishery. Up to 50 crews of as many as 4 people per crew have participated in this winter (February-March) fishery. Trammel nets are used and the crews are allowed to harvest carp, buffalo, drum, carpsuckers, bowfin, and gar. Most of the catch consists of bigmouth buffalo, smallmouth buffalo, carp, and carpsuckers. In 1974, the first year of the program, 98,900 kg (218,000 lbs) were harvested. In the second year, 812,000 kg (1.79 million lbs) of fish from the Carlyle fishery were marketed. Based on the joint-use pool of 10,522 ha (26,000 ac), the 1975 commercial fish harvest amounted to 77 kg/ha (68.8 lbs/ac), having an estimated value of \$340,000 (38).

The discovery that the commercial fishes were contaminated with dieldrin forced the closure of this fishery during 1976 and 1977. The earlier ban

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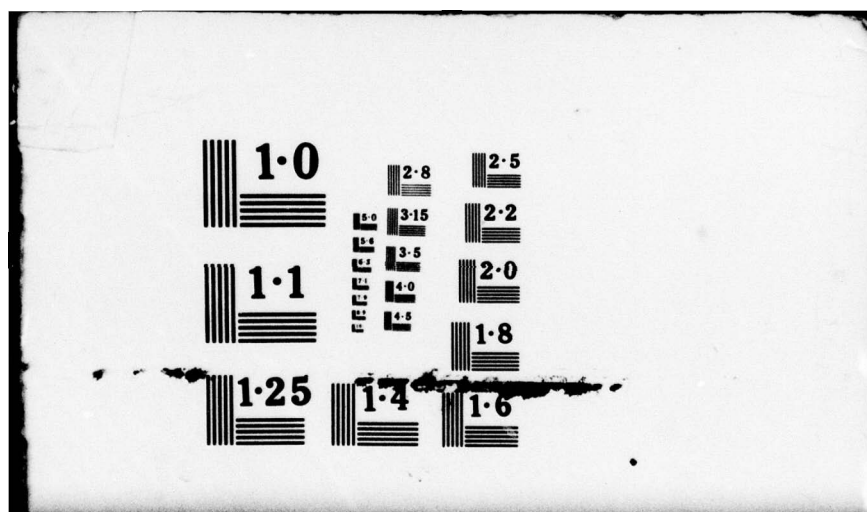
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on dieldrin was apparently successful as the commercial fishery at Carlyle was again permitted in 1978. In spite of extremely bad ice cover and weather conditions, an estimated 158,760 kg (350,000 lbs) were harvested in 1978 (Arnold Fritz, pers. comm., 1978).

Fishery Resources -- Evaluation of Planning Input

Fishery planning for the Carlyle Lake project progressed through three rather distinct phases. The first planning recommendations were contained in the FWS's 1954 report. By and large, the FWS report reflected acceptance of existing CE design features and the incidental fishery benefits which would occur as a result of the construction and operational plans that were already formulated. Among the FWS's recommendations which fell into this category were: (1) maintenance of a minimum annual pool at elevation 429.5, (2) a minimum discharge of 50 cfs, and (3) a low-level reservoir discharge. The report strongly emphasized the necessity of eliminating potential water quality degradation associated with inundation of the oil wells and associated developments within the reservoir basin. All of these features have been implemented by the construction agency.

Two additional fishery-related recommendations of a very general nature were provided, viz: (1) operate reservoir to benefit lake fishery consistent with primary project purposes, and (2) control bank erosion around the lake perimeter. No specific operations schedule was suggested to benefit the fishery and no specific actions relating to prevention of shoreline erosion were advanced.

Correspondingly vague responses to these two recommendations were provided

by the construction agency (6), viz:

Consistent with the primary purposes of the impoundments, the reservoirs would be operated so as to provide maximum benefit to fish and wildlife resources.

The plan of reservoir operation does not envision rapid draw-downs which would accelerate bank erosion.

No further communications or more specific discussions of these aspects of project construction and operation were exchanged until after the lake was flooded and in operation. Each subject, i.e., shoreline erosion and drawdown schedules, then became matters of considerable discussion and activity.

One specific recommendation contained in the 1954 FWS report, i.e., clear all timber from the 10,522 ha (26,000 ac) navigation pool, was later modified to provide for a 3,642 ha (9,000 ac) uncleared area in the upper reaches of the lake basin. Boat lanes were cleared in the standing timber area to facilitate angling and boat traffic.

Basically, this summarizes the initial planning input of 1954. Federal (FWS) involvement was then seemingly replaced by more active state assistance which comprised the second phase of fishery planning. The major product of this direct state-CE pre-impoundment communication (FWS largely monitored) was a state plan to utilize existing bottomland lakes within the Carlyle Lake basin as brood ponds which would be stocked with largemouth bass and then inundated by the rising waters of Carlyle Lake. This plan was later modified to provide for stocking the lakes with fingerling largemouth bass (Arnold Fritz, pers. comm., 1978).

The third phase of fishery planning has been the continuing activities

following completion and impoundment of Carlyle Lake. Perhaps the most concrete result of these efforts has been the cooperatively constructed (CE and IDC) nursery pond of 2 ha (5 ac).

Carlyle Lake currently supports a diverse and regionally important recreational fishery. Several species native to the Kaskaskia River developed significant reservoir populations. This list includes largemouth bass, crappie, channel catfish, carp, freshwater drum, and several other species. Although white bass were native to the Kaskaskia River, there was no evidence of successful reproduction by those fish which may have been confined to the lake when impounded. Adult white bass were planted on several occasions and it is believed that the existing lake population was produced from these introduced fish.

The lake also provided an opportunity to diversify recreational fishing opportunities through the introduction of non-native game fish species. Two such species, walleye and northern pike, have been stocked. The walleye has become an increasingly important species in the catch, particularly from the stilling basin below the dam. Northern pike were not introduced until 1977, and their survival and contribution to the recreational fishery have not been documented as yet.

Although some reproduction, disease, and food problems exist for certain of the sport fish species, the fish community at Carlyle is believed to be in satisfactory condition. This post-impoundment lake fishery was correctly anticipated by the pre-impoundment planners -- with the notable exception of the introduction of non-native fishes. The basic water fluctu-

ation and turbidity problems were correctly portrayed.

Many of the FWS's comments related to the necessity of eliminating the potential pollution problems associated with flooding oil fields. Oil, phenol, and brine contaminants would have greatly diminished the project-related fishery values had corrective action not been taken by the construction agency.

A major adverse influence associated with the Carlyle and Shelbyville projects was the later reallocation of storage for the lower Kaskaskia navigation project. At the time of initial planning for Carlyle, the construction agency did not anticipate the Kaskaskia River navigation benefits which were later authorized (1962) and incorporated into the project. Thus, the consideration of all project-related influences, including downstream impacts, were never contained in one comprehensive report. Storage in Shelbyville and Carlyle for navigation facilitated the Kaskaskia Navigation Project, which converted 51 miles of the lower Kaskaskia River below Carlyle Lake to a 36 mile canal with lock and dam, extending from Fayetteville, Illinois, to the river's mouth (43). Although considered separately by the affected agencies in 1964 (44), a synoptic evaluation of all Carlyle/Shelbyville-associated impacts on fisheries resources would have more clearly depicted project impacts than did the separate studies of individual project components which were carried out over a period of years.

A maximum 10,000 cfs non-damaging downstream release was programmed into the Carlyle project. Releases of this magnitude were made initially and

the flow releases were rapidly increased and decreased. This discharge regime proved to be highly detrimental to stream banks and low lying stream-side agricultural lands. Currently, the maximum non-damage release is considered to be only 4,000 cfs instead of the previously calculated 10,000 cfs. The rate at which discharges are increased and decreased has also been moderated to reduce the stream bank sloughing problem.

The Kaskaskia River below Carlyle Lake was expected to benefit slightly (\$1,000 annual benefit) as a result of the 50 cfs minimum flow to be released from the lake through a bottom outlet. These beneficial effects were expected to offset the loss of the shallow oxbow lakes downstream from the project, anticipated to result from development of the auxiliary levee system. The total value of the downstream river fishery (to New Athens) was placed at \$12,000 annually, in the absence of pollution problems. This is assumed to have represented an expected fishing effort and harvest of 6,360 trips and 4,560 kg (10,053 lbs), respectively, and a commercial harvest of 12,000 kg (26,455 lbs).

The fish community located in the Kaskaskia River below Carlyle may have benefitted at times from improvements in water quality and quantity induced by the 50 cfs minimum release and the reduction in suspended sediment loads.

However, extended periods of 50 cfs releases are believed to adversely impact the aquatic community of the Kaskaskia River (Tom Johnson, pers. comm., 1978). Also, there are some commercial fishermen who believe the

prevention of high flood flows has retarded the customary attraction of commercially harvested species into the Kaskaskia River from the Mississippi River (Weldon Larimore, pers. comm., 1978). Unfortunately, no surveys of the downstream river sport or commercial fisheries have been conducted. The scheduling of downstream releases and the negative impact on the downstream biota during extended releases of only 50 cfs, are currently subjects of considerable interest and discussion (Edwin Herricks, pers. comm., 1978). A committee comprised of representatives of various affected agencies are examining the entire question of Kaskaskia River flows.

In the absence of pollution, Carlyle Lake was expected to support a recreational fishery valued at \$52,300 in terms of projected angler expenditures. Conversion of this early (1954) monetary figure to the equivalent value of a more recent year (1970) was accomplished by means of the U.S. Department of Labor price index (45). The 1970 equivalent of the 1954 value of \$52,300 was \$75,560. The year 1970 was selected because of the IDC expenditure study which was carried out that year. The IDC's 1970 study revealed the Carlyle project's recreational fishery to be worth much more than \$76,000 (42), viz:

Assuming there were as many fishermen in 1970 as in 1969 and using the determined \$5.00 expenditure per fisherman trip, it can be estimated that at least \$640,000 were spent by the Carlyle area anglers to enjoy their sport. Since there is no estimation as to the number of fishermen using the Carlyle area from November 1st to March 31st, the above figure does not represent the total value of the fishery. It is possible that the total expenditures made by Carlyle area anglers may have exceeded three quarters of a million dollars annually.

At three quarters of a million dollars the value of the reservoir fishery would have been 10 times greater than the expected value of \$75,560 (equi-

valent to \$52,300 in 1954).

The angler-use and harvest figures of 30,000 to 36,000 trips and 29,000 kg (64,000 lbs), assumed to have been predicted for the post-impoundment fishery, fall considerably below prevailing effort and harvest levels at the lake. Actual harvest and angling-use levels are five to six times greater than the predicted levels (Table 28).

Although commercial fishing at Carlyle has been allowed during only three seasons, it would appear from the available catch data that the lake provides a greater potential commercial fishing resource than was expected.

Table 28. -- Comparison of angling-effort and harvest predictions (1954), and actual effort and harvest data (1977) for Carlyle Lake and tailrace

	Angler-trips	Harvest	
		Recreational kg (lbs)	Commercial kg (lbs)
Predicted	30,000 - 36,000	29,000 (64,000)	22,853 (50,382)
Actual	162,000 - 188,000	180,000 - 205,000 (397,000 - 452,000)	357,000* (786,000)

* Average of 1974, 1975, and 1978 catches (only years with legal commercial season)

SUMMARY

Carlyle Lake, which covers 10,522 ha (26,000 ac) at normal pool is the largest impoundment in the State of Illinois. Located only 80 km (50 mi) east of St. Louis, Missouri, the lake is a popular recreational facility and the fish and wildlife populations associated with the project are important, heavily exploited natural resources. The project was constructed by the St. Louis District of the Corps of Engineers (CE), being completed in 1967.

Ample time and authority was available to the Fish and Wildlife Service (FWS) to address adequately the impacts of the Carlyle Lake project on fish and wildlife resources. The FWS report was prepared in 1954 and this report was appended to the CE survey report which was submitted to Congress in 1957. The project was authorized by the Flood Control Act of 1958, and therefore fell under the full purview of the 1958 Amendments to the Fish and Wildlife Coordination Act. Construction of the dam and lake began in 1964 and the project was completed in 1967.

In their 1954 planning report, the FWS provided 12 separate fish and wildlife-related planning recommendations. Several of these recommendations constituted affirmations of proposed CE design and operational plans for the project; viz, a conservation pool at elevation 429.5 ft. msl, minimum flow of 50 cfs, and a bottom water discharge. Several other recommendations were important, though pro forma articles which were generally contained in every FWS report of that time-period, viz, all federally-owned land be open to the public, leased land must stipulate right of public

access, and administration of wildlife lands to be by state agency under a general plan. The remaining six recommendations were site specific (i.e., specifically related to Carlyle project). Five of these recommended actions were: (1) operate reservoir to benefit fish and wildlife, consistent with primary project purposes, (2) efforts be made to control bank erosion, (3) develop interagency plan to remedy potential oil pollution problem prior to construction, (4) manage lands between annual pool and "taking line" for wildlife whenever feasible, and (5) clear timber and brush within limits of navigation pool. With the important exception of the last (no. 5) recommendation which was later amended, at the request of the conservation agencies, to allow standing timber to remain in the upper section of the summer pool, all five of these recommendations were implemented by the construction agency.

The final recommendation submitted by the FWS was not implemented by the CE. This important exception related to the acquisition of additional land for wildlife. The wording of the FWS recommendation did not indicate that acquisition of the land was necessary for mitigation or compensation of project-caused losses. The wording (4) was as follows:

Tracts of land nearly surrounded by water of the reservoir at flood-control pool level be acquired by the project planning agency and managed for the betterment of wildlife by the State of Illinois.

The CE's response (6) was:

The majority of the areas suggested by the Fish and Wildlife Service for State management would be in the flowage-easement category with ownership remaining with the individual. It appears doubtful that State management would be practical in such areas.

In any event, the CE concluded (or cit.):

The designation of areas of land to be set aside for wildlife would have to be coordinated by the Fish and Wildlife Service or appropriate State agency with individual landowners.

The CE acquired in fee only those lands up to the programmed five-year flood frequency elevation or 137.2 m (450 ft) m.s.l. Cooperative planning efforts between the construction agency and the FWS were practically non-existent between 1954 and completion of the project in 1967. However, the State of Illinois submitted a development plan to the CE (1961) to convert the upper section of the project-acquired acreage into a waterfowl management area. The objective was to construct a system of controlled sub-impoundments to create a "green-tree" management complex.

The sub-impoundment design (top of dikes) relied upon the CE's programmed storage elevations of 135.6 m (445.0 ft) msl (mean sea level) at normal pool, 136.3 m (447.1 ft) msl at annual flood pool, and 137.2 m (450 ft) msl at five-year flood pool. The sub-impoundment dikes were constructed by the State with a crown elevation of 137.2 m (450 ft) msl. Flood-water storage since project completion has exceeded the 137.2 m (450 ft) msl elevation during 7 years of the 11 years of record. In 1973 and 1974, flood water was retained behind the dam (including flooding sub-impoundments), for long periods during the growing season. As a result, approximately 80 percent of the fast-producing trees located in the sub-impoundment area were killed. Although no facilities were incorporated by the State to pump water out of the sub-impoundments, the reservoir was filled above the top of the dikes for long periods so that dewatering the sub-

impoundments would not have been possible in 1973 and 1974 had pumps been installed.

Although the reservoir-sub-impoundment complex has not operated successfully as a green-tree facility as originally planned, the planted waterfowl food plots in the sub-impoundment area, in conjunction with the broad expanse of open water provided by the lake, have created what is characterized as the single most important public waterfowl area in the State of Illinois (26). Waterfowl use of the project area is markedly higher than it was prior to construction of the project, having increased from approximately one million duck-days/year (pre-project) to just under seven million duck-days/year (post-project). Goose use of the project area also increased dramatically -- from a negligible amount in the absence of the project to just over one million goose-days annually following project completion. Harvest of waterfowl has averaged approximately 7,550 birds annually (200 geese; remainder ducks) during recent years.

Several other wildlife species have been adversely impacted by the combination of permanent inundation of the 10,522 ha (26,000 ac) normal pool and the paucity of project lands suitable for management of terrestrial wildlife resources. Losses in squirrel, rabbit, quail, opossum, and fox populations were predicted to occur as a result of project construction and, indeed, serious losses have occurred. In fact, the apparent losses have far exceeded the pre-project estimated losses for all of these species, except fox.

The IDC maintains an adult pheasant stocking program (put-and-take) on pro-

ject lands. This program supports a large number of hunter-days. Project area populations of two species, white-tailed deer and raccoon, have exhibited increases since the project was constructed. Contrary to the expected severe impact on deer (viz, "greatly reduce the chance of success in developing a permanent deer herd in the Kaskaskia Basin"), it is clear that the project impacts on deer resources were localized and directly related to the amount of deer habitat flooded by the permanent pool.

The Carlyle Lake fishery is vastly superior to the expected conditions. The introduction of fish, though not considered in the pre-construction period, has contributed greatly to this valuable recreational enterprise. Angling effort on the lake and tailrace is approximately 5.3 times the level predicted, and the recreational harvest is approximately 6.6 times higher than predicted. This fishery would have been seriously jeopardized by poor water quality had the potential oil pollution problem not been alleviated by the construction agency, a program strongly supported by the early FWS planners. Commercial fish harvest has also exceeded the level projected, although a fish contamination problem (currently considered to be abated) could again deprive local commercial anglers of the continued use of this resource.

After project construction, the Kaskaskia River channel below the dam suffered serious bank erosion and sloughing as a direct result of project operation compounded by the miscalculation of the non-damaging channel capacity by the construction agency. Flood-water releases, in terms of both procedure and volume, have been moderated by the CE to curtail the

stream-bank degradation problem.

Although the 50 cfs minimum release from the project was implemented, the subject of water management within the entire Kaskaskia River system is currently receiving inter-agency study. A possible result of the study could be increased low flow and improvement of the current river conditions during drought conditions.

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